



SCIENTIA NAVALIS
VENTORUM
MALISQUE DOMINATRIX

SEAMANSHIP,

BOTH IN

THEORY AND PRACTICE.

ILLUSTRATED WITH ENGRAVINGS.

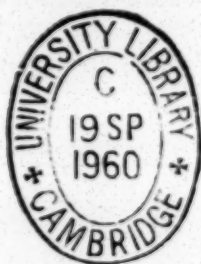
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P R E F A C E.

“THE ELEMENTS AND PRACTICE OF RIGGING, SEAMANSHIP, AND NAVAL TACTICS,” a work in two volumes quarto, was last year presented to the public.

The re-publication of it, in a smaller form and in single volumes, each containing one subject, has been called for from the proprietor, by a large portion of the naval world, as an object of peculiar convenience and advantage to them. In compliance, therefore, with that wish, the present treatise on SEAMANSHIP is now announced.

The working of ships depends on principles of mathematical form and origin: but the early authors who developed it scientifically have been found too abstruse for general use; and of this description were the Pere Hofte and M. Bouguer. They afforded materials, however, that form the basis of that theory which was afterwards produced by M. Bourdé de Villehuet, the truth and utility of which have been confirmed by experience. This latter gentleman

has treated the laws of motion in fluids, with regard to ships, and the effects of the different sails and rudder, in a manner equally correct and more accessible to general comprehension. But he has, in the humble opinion of the editor, performed a more essential service to maritime nations, by shewing the exact correspondence of practice with theory, the one accompanying the other, as the rule and its example : by which not only is the truth of this science established, but nautical students are led on to argue from effect to cause, and to make themselves masters of that upon principle, which else they could know only from practice.

In the present volume, therefore, will be found a more correct translation of M. Bourdé's work, named *Le Manœuvrier*, and a large collection of practical directions for the management of ships, in calm or storm, in harbour or on the ocean.

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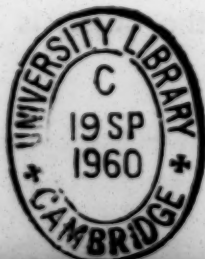
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THE THEORY AND PRACTICE OF WORKING SHIPS.

THE working of ships, like other sciences, consists of theory and practice. The knowledge of a theory, which is founded upon unerring principles, is surely indispensable for the correct attainment of the practice which it guides; and it cannot therefore be useless to shew that the theory of working ships is supported by mathematical principles, and capable of convincing demonstration.

To the theoretic part are superadded directions for the performance of many evolutions, accompanied with DEMONSTRATIONS of the agreement of each with the mathematical principles before laid down. The whole, we trust, will form the most extensive collection ever yet brought together; and all founded, we equally hope, upon the surest principles.

But we do not affect to give specific directions for every possible situation of a ship at sea; because, if such directions could be given, they would most likely be unserviceable from their bulk: but, in explaining the theory upon which all nautical operations ought to be founded, we impart an unfailing source of knowledge to the seaman. Those principles will be his surest safeguard in the hour of danger, and his best assistant in the time of untried difficulty.



B

EXPLANATION

EXPLANATION OF THE TERMS USED IN SEAMANSHIP.

A BACK. The situation of the sails, when their surfaces are pressed aft against the mast by the force of the wind.

ABAF. The hinder part of a ship, or towards the stern. It also signifies *farther aft* or *nearer to the stern*; as, the barricade stands **ABAF** the main mast; that is, nearer to the stern.

ABAF THE BEAM denotes the relative situation of any object with the ship, when the object is placed in any part of that arch of the horizon, which is contained between a line at right angles with the keel and that point of the compass which is directly opposite to the ship's course. See **BEARING**.

ABOARD. The inside of a ship.

ABOARD MAIN TACK! The order to draw the lower corner of the mainsail down to the cheftree.

ABOUT. The situation of a ship as soon as she has tacked or changed her course.

ABOUT SHIP! The order to the ship's crew to prepare for tacking.

ABREAST. The situation of two or more ships lying with their sides parallel, and their heads equally advanced; in which case, they are abreast of each other, as are the ships A B C.

But, if their sides be not parallel, then that ship, which is in a line with the beam of the other, is



said

said to be abreast of her, as the ship E is abreast of D and F. With regard to objects within the ship, it implies on a line parallel with the beam, or at right angles with the ship's length. **ABREAST OF ANY PLACE,** means off or directly opposite to it.



ADRIFT. The state of a ship broken from her moorings, and driving about without controul.

AFLOAT. Buoyed up by the water from the ground.

AFORE. All that part of a ship which lies forward, or near the stem. It also signifies *farther forward*; as, the manger stands **AFORE** the fore-mast; that is, nearer to the stem.

AFT. Behind, or near the stern of the ship.

AFTER. A phrase applied to any object in the hinder part of the ship, as the after-hatchway, the after-fails, &c.

A-GROUND. The situation of a ship when her bottom or any part of it rests on the ground.

A-HEAD. Any thing, which is situated on that point of the compass to which a ship's stem is directed, is said to be a-head of her. See **BEARING.**

A-HULL. The situation of a ship, when all her sails are furled and her helm is lashed to the lee side; by which she lies nearly with her side to the wind and sea, her head being somewhat inclined to the direction of the wind.

A-LEE. The position of the helm when it is pushed down to the lee side.

ALL IN THE WIND. The state of a ship's sails, when they are parallel to the direction of the wind, so as to shake or shiver.

ALL HANDS HOAY! The call by which all the ship's company are summoned upon deck.

ALOFT. Up in the tops, at the mast-heads, or any where about the higher rigging.

ALONG-SIDE. Side-by-side, or joined to a ship, wharf, &c.

ALONG-SHORE. Along the coast; a course which is in sight of the shore, and nearly parallel to it.

AMAIN. At once, suddenly: as, **LET GO AMAIN!**

AMIDSHIPS. The middle of a ship, either with regard to her length or breadth.

To ANCHOR. To let the anchor fall into the ground, for the ship to ride thereby.

ANCHORAGE. Ground, fit to hold a ship by her anchor.

THE ANCHOR IS A COCK-BILL. The situation of the anchor, when it drops down perpendicularly from the cat-head, ready to be sunk at a moment's warning.

AN-END. The position of any mast, &c. when erected perpendicularly on the deck. The top-masts are said to be **AN-END** when they are hoisted up to their usual stations.

APEEK. Perpendicular to the anchor; the cable having been drawn so tight as to bring the ship directly over it. The anchor is then said to be **APEEK**.

ASHORE. On the shore, as opposed to **ABOARD**. It also means **A-GROUND**.

ASTERN. Any distance behind a ship, as opposed to **A-HEAD**. See **BEARING**.

AT ANCHOR. The situation of a ship riding by her anchor.

ATHWART. Across the line of a ship's course.

ATHWART-HAWSE. The situation of a ship when driven by accident across the fore-part of another, whether they touch or are at a small distance from each other, the transverse position of the former being principally understood.

ATHWART THE FORE FOOT. When any object crosses the line of a ship's course, but a-head of her, it is said to be **ATHWART HER FORE FOOT**.

ATHWART-SHIPS. Reaching, or in a direction, across the ship from one side to the other.

ATRIP. When applied to the anchor, it means that the anchor is drawn out of the ground, and hangs, in a perpendicular direction, by the cable or buoy-rope. The topmasts are said to be **ATRIP**, when they are hoisted up to the mast-head, or to their utmost extent.

AVAST! The command to stop, or cease, in any operation.

AWEIGH.

AWEIGH. The same as **ATRIP**, when applied to the anchor.

To BACK THE ANCHOR. To carry out a small anchor ahead of the large one, in order to support it in bad ground, and to prevent it from loosening or coming home.

To BACK ASTERN, in rowing, is to impel the boat with her stern foremost, by means of the oars.

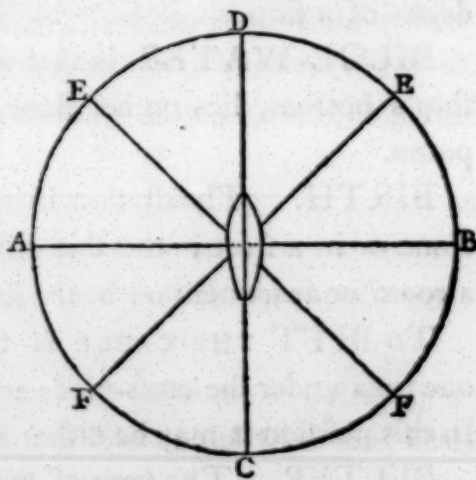
To BACK THE SAILS. To arrange them in a situation that will occasion the ship to move a-stern.

To BAGPIPE THE MIZEN. To lay it a-back, by bringing the sheet to the mizen-shrouds.

To BALANCE. To contract a sail into a narrower compass, by folding up a part of it at one corner. **BALANCING** is peculiar only to the mizen of a ship, and the mainfail of those vessels wherein it is extended by a boom.

BARE POLES. When a ship has no sail set, she is **UNDER BARE POLES**.

BEARING. The situation of one place from another, with regard to the points of the compass. The situation also of any distant object, estimated from some part of the ship, according to her situation: these latter bearings are either **ON THE BEAM**, as A and B; **BEFORE THE BEAM**, as the arcs AD and DB; **ABAFT THE BEAM**, as the arcs AC and CB; **ON THE LEE OR WEATHER BOW**, as the lines EE; **ON THE LEE OR WEATHER QUARTER**, as the lines FF; **A-HEAD**, as the line D; **OR A-STERN**, as the line C.



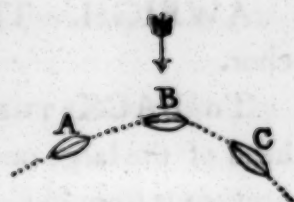
BEAR A-HAND. Make haste, dispatch.

To BEAR IN WITH THE LAND is when a ship fails towards the shore.

To BEAR OF. To thrust or keep off from the ship's side, &c. any weight, when hoisting.

T.

TO BEAR UP, OR AWAY. The act of changing a ship's course, to make her sail more before the wind. Thus the ship A bears away from a close-hauled course, when she gets into either of the courses B and C.



BEATING TO WINDWARD. The making a progress against the direction of the wind, by steering alternately close-hauled on the starboard and larboard tacks.

TO BECALM. To intercept the current of the wind, in its passage to a ship, by any contiguous object, as a shore above her sails, a high sea behind, &c. and thus one sail is said to becalm another.

BEFORE THE BEAM denotes an arch of the horizon comprehended between the line of the beam and that point of the compass on which the ship stems. See **BEARING**.

TO BELAY. To fasten a rope, by winding it several times round a cleat or pin.

TO BEND A SAIL is to affix it to its proper yard or stay.

BENEAPED. See **NEAPED**.

BETWEEN-DECKS. The space contained between any two decks of a ship.

BILGE-WATER is that which, by reason of the flatness of a ship's bottom, lies on her floor, and cannot go to the well of the pump.

BIRTH. The station in which a ship rides at anchor, either alone or in a fleet; the due distance between two ships; and also a room or apartment on board for the officers of a mess.

TO BITT THE CABLE is to confine the cable to the bitts, by one turn under the cross-piece and another turn round the bitt-head. In this position it may be either kept fixed or it may be veered away.

BITTER. The turn of the cable round the bitts.

BITTER-END. That part of the cable which stays within-board round about the bitts when the ship is at anchor.

A BOARD is the distance run by a ship on one tack; thus they say, *a good board*, when a ship does not go to leeward of her course; a *short board* and a *long board*, according to the distance run.

BOARD-

BOARD-AND-BOARD. When two ships come so near as to touch each other, or when they lie side-by-side.

TO BOARD A SHIP. To enter an enemy's ship in an engagement.

BOLD SHORE. A steep coast, permitting the close approach of shipping.

BOOT-TOPPING. Cleaning the upper part of a ship's bottom, or that part which lies immediately under the surface of the water; and daubing it over with tallow, or with a mixture of tallow, sulphur, rosin, &c.

BOTH SHEETS AFT. The situation of a ship sailing right before the wind.

BOW-GRACE. A frame of old rope or junk, laid out at the bows, stems, and sides, of ships, to prevent them from being injured by flakes of ice.

TO BOWSE. To pull upon any body with a tackle, in order to remove it.

BOXHAULING. A particular method of veering a ship, when the swell of the sea renders tacking impracticable.

BOXING. An operation somewhat similar to BOXHAULING. It is performed by laying the head-sails aback, to receive the greatest force of the wind in a line perpendicular to their surfaces, in order to return the ship's head into the line of her course, after she had inclined to windward of it.

TO BRACE THE YARDS. To move the yards, by means of the braces, to any direction required.

TO BRACE ABOUT. To brace the yards round for the contrary tack.

TO BRACE SHARP. To brace the yards to a position, in which they will make the smallest possible angle with the keel, for the ship to have head-way.

TO BRACE-TO. To ease off the lee-braces, and round in the weather-braces, to assist the motion of the ship's head in tacking.

TO BRAIL UP. To haul up a sail by means of the brails, for the more readily furling it when necessary.

BRAILS.

BRAILS. A name peculiar only to certain ropes belonging to the mizen, used to truss it up to the mast. But it is likewise applied to all the ropes which are employed in hauling up the bottoms, lower corners, and skirts, of the other great sails.

To BREAK BULK. The act of beginning to unload a ship.

To BREAK SHEER. When a ship at anchor is forced, by the wind or current, from that position in which she keeps her anchor most free of herself and most firm in the ground, so as to endanger the tripping of her anchor, she is said to break her sheer.

BREAMING. Burning off the filth from a ship's bottom.

BREAST-FAST. A rope employed to confine a ship sideways to a wharf or to some other ship.

To BRING BY THE LEE. See **TO BROACH TO.**

To BRING TO. To check the course of a ship when she is advancing, by arranging the sails in such a manner as that they shall counteract each other, and prevent her from either retreating or advancing. See **TO LIE TO.**

To BROACH TO. To incline suddenly to windward of the ship's course, so as to present her side to the wind, and endanger her oversetting. The difference between **BROACHING TO** and **BRINGING BY THE LEE** may be thus defined: Suppose a ship under great sail is steering south, having the wind at N.N.W. then west is the weather-side, and east the lee-side. If, by any accident, her head turns round to the westward, so as that her sails are all taken a-back on the weather side, she is said to **BROACH TO.** If, on the contrary, her head declines so far eastward as to lay her sails aback on that side which was the lee-side, it is called **BRINGING BY THE LEE.**

BROADSIDE. A discharge of all the guns on one side of a ship both above and below.

BROKEN BACKED. The state of a ship which is so loosened in her frame as to drop at each end.

BY THE BOARD. Over the ship's side.

BY

BY THE HEAD. The state of a ship when she is so unequally loaded as to draw more water forward than aft.

BY THE WIND. The course of a ship as near as possible to the direction of the wind, which is generally within six points of it.

To CAREEN. To incline a ship on one side so low down, by the application of a strong purchase to her masts, as that her bottom on the other side may be cleansed by breaming.

CASTING. The motion of falling off, so as to bring the direction of the wind on either side of the ship after it had blown some time right a-head. It is particularly applied to a ship about to weigh anchor.

To CAT THE ANCHOR is to hook the cat-block to the ring of the anchor and haul it up close to the cat-head.

CAT's PAW. A light air of wind perceived at a distance in a calm, sweeping the surface of the sea very lightly, and dying away before it reaches the ship.

CENTRE. This word is applied to that squadron of a fleet, in line of battle, which occupies the middle of the line; and to that column (in the order of sailing) which is between the weather and lee columns.

CHANGE THE MIZEN. Bring the mizen-yard over to the other side of the mast.

CHAPELLING. The act of turning a ship round in a light breeze of wind when she is closed-hauled, so as that she will lie the same way she did before. This is usually occasioned by negligence in steering or by a sudden change of wind.

CHASE. A vessel pursued by some other.

CHASER. The vessel pursuing.

CHEERLY. A phrase implying heartily, quickly, cheerfully.

To CLAW OFF. The act of turning to windward from a lee-shore to escape shipwreck, &c.

CLEAR is variously applied. The weather is said to be **CLEAR**, when it is fair and open; the sea-coast is **CLEAR**, when the navigation is not interrupted by rocks, &c. It is applied to cordage,

C

cables,

BY

cables, &c. when they are disentangled, so as to be ready for immediate service. In all these senses it is opposed to **FOUL**.

To **CLEAR THE ANCHOR** is to get the cable off the flukes, and to disencumber it of ropes ready for dropping.

CLEAR HAWSE. When the cables are directed to their anchors without lying athwart the stem.

To **CLEAR THE HAWSE** is to untwist the cables when they are entangled by having either a cross, an elbow, or a round turn.

CLENCHED. Made fast, as the cable is to the ring of the anchor.

CLOSE-HAULED. That trim of the ship's sails, when she endeavours to make a progress in the nearest direction possible towards that point of the compass from which the wind blows.

To **CLUB-HAUL.** A method of tacking a ship when it is expected she will miss stays on a lee-shore.

To **CLUE UP.** To haul up the clues of a sail to its yard by means of the clue-lines.

COASTING. The act of making a progress along the sea-coast of any country.

To **COIL THE CABLE.** To lay it round in a ring, one turn over another.

To **COME HOME.** The anchor is said to come home when it loosens from the ground by the effort of the cable, and approaches the place where the ship floated, at the length of her moorings.

COMING TO denotes the approach of a ship's head to the direction of the wind.

COURSE. The point of the compass on which a ship steers.

CRANK. The quality of a ship, which, for want of sufficient ballast, is rendered incapable of carrying sail without being exposed to the danger of oversetting.

To **CROWD SAIL.** To carry more sail than ordinary.

CUNNING. The art of directing the steersman to guide the ship in her proper course.

To

TO CUT AND RUN. To cut the cable and make sail instantly, without waiting to weigh anchor.

TO DEADEN A SHIP'S WAY. To impede her progress through the water.

DEAD WATER. The eddy of water, which appears like whirl-pools, closing in with the ship's stern as she sails on.

DISMASTED. The state of a ship that has lost her masts.

DOUBLING. The act of sailing round or passing beyond a cape or point of land.

DOUBLING UPON. The act of inclosing any part of a hostile fleet between two fires, or of cannonading it on both sides.

TO DOWSE. To lower suddenly, or slacken.

TO DRAG THE ANCHOR. To trail it along the bottom, after it is loosened from the ground.

TO DRAW. When a sail is inflated by the wind, so as to advance the vessel in her course, the sail is said **TO DRAW**; and so **TO KEEP ALL DRAWING** is to inflate all the sails.

DRIFT. The angle which the line of a ship's motion makes with the nearest meridian, when she drives with her side to the wind and waves, and not governed by the power of the helm. It also implies the distance which the ship drives on that line.

DRIVING. The state of being carried at random, as impelled by a storm or current. It is generally expressed of a ship when accidentally broke loose from her anchors or moorings.

DROP. Used sometimes to denote the depth of a sail; as the fore-top-sail **DROPS** twelve yards.

TO DROP ANCHOR. Used synonymously with **TO ANCHOR**.

TO DROP A-STERN. The retrograde motion of a ship.

TO EASE, TO EASE AWAY, OR TO EASE OFF. To slacken gradually; thus they say, **EASE** the bowline, **EASE** the sheet.

EASE THE SHIP! The command given by the pilot, to the steersman, to put the helm hard a-lee, when the ship is expected to plunge her fore part deep in the water when close-hauled.

TO EDGE AWAY. To decline gradually from the shore or from the line of the course which the ship formerly held, in order to go more large.

To EDGE IN WITH. To advance gradually towards the shore or any other object.

ELBOW IN THE HAWSE. A particular twist in the cables by which a ship is moored; explained at length hereafter in the PRACTICE OF WORKING SHIPS.

END-FOR-END. A reversal of the position of any thing is turning it **END-FOR-END**. It is applied also to a rope that has run quite out of the block in which it was reeved, or to a cable which has all run out of the ship.

END ON. When a ship advances to a shore, rock, &c. without an apparent possibility of preventing her, she is said to go **END ON** for the shore, &c.

EVEN KEEL. When the keel is parallel with the horizon, a ship is said to be upon an **EVEN KEEL**.

FAIR. A general term for the disposition of the wind when favourable to a ship's course.

FAIR-WAY. The channel of a narrow bay, river, or haven, in which ships usually advance in their passage up and down.

To FALL A-BOARD OF. To strike or encounter another ship when one or both are in motion.

To FALL A-STEM. The motion of a ship with her stern foremost.

To FALL CALM. To become in a state of rest by a total cessation of the wind.

To FALL DOWN. To sail or be towed down a river nearer towards its mouth.

FALLING OFF denotes the motion of the ship's head from the direction of the wind. It is used in opposition to **COMING TO**.

FALL NOT OFF! The command to the steersman to keep the ship near the wind.

To FETCH WAY. To be shaken or agitated from one side to another so as to loosen any thing which was before fixed.

To FILL. To brace the sails so as to receive the wind in them, and advance the ship in her course, after they had been either shivering or braced a-back.

To

TO FISH THE ANCHOR. To draw up the flukes of the anchor towards the top of the bow, in order to stow it, after having been catted.

FLAT-AFT. The situation of the sails when their surfaces are pressed aft against the mast by the force of the wind.

TO FLAT IN. To draw in the aftermost lower corner or clue of a sail towards the middle of the ship, to give the sail a greater power to turn the vessel.

TO FLAT IN FORWARD. To draw in the fore-sheet, jib-sheet, and fore-staysail-sheet, towards the middle of the ship.

FLAW. A sudden breeze or gust of wind.

FLOATING. The state of being buoyed up by the water from the ground.

FLOOD-TIDE. The state of a tide when it flows or rises.

FLOWING SHEETS. The position of the sheets of the principal sails when they are loosened to the wind, so as to receive it into their cavities more nearly perpendicular than when close-hauled, but more obliquely than when the ship sails before the wind. A ship going two or three points large has **FLOWING SHEETS**.

FORE. That part of a ship's frame and machinery that lies near the stem.

FORE-AND-AFT. Throughout the whole ship's length. Lengthways of the ship.

TO FORE-REACH UPON. To gain ground of some other ship.

TO FORGE OVER. To force a ship violently over a shoal by a great quantity of sail.

FORWARD. Towards the fore part of a ship.

FOUL. Is used in opposition both to **CLEAR** and **FAIR**. As opposed to **CLEAR**, we say **FOUL WEATHER**, **FOUL BOTTOM**, **FOUL GROUND**, **FOUL ANCHOR**, **FOUL HAWSE**. As opposed to **FAIR**, we say **FOUL WIND**.

TO FOUNDER. To sink at sea by filling with water.

TO FREE. Pumping is said to **FREE** the ship when it discharges more water than leaks into her.

To

TO FRESHEN. When a gale increases it is said to **FRESHEN**.

TO FRESHEN THE HAWSE. Veering out or heaving in a little cable to let another part of it endure the stress at the hawse-holes. It is also applied to the act of renewing the service round the cable at the hawse-holes.

FRESH WAY. When a ship increases her velocity she is said to get **FRESH WAY**.

FULL. The situation of the sails, when they are kept distended by the wind.

FULL-AND-BY. The situation of a ship, with regard to the wind, when close-hauled; and sailing, so as to steer neither too nigh the direction nor to deviate to leeward.

TO FURL. To wrap or roll a sail close up to the yard or stay to which it belongs, and winding a cord round it, to keep it fast.

TO GAIN THE WIND. To arrive on the weather-side, or to windward of, some ship or fleet in sight, when both are sailing as near the wind as possible.

TO GATHER. A ship is said to gather on another as she comes nearer to her.

GIMBLETING. The action of turning the anchor round by the stock, so that the motion of the stock appears similar to that of the handle of a gimblet, when employed to turn the wire.

TO GIVE CHASE TO. To pursue a ship or fleet.

GOOSE-WINGS OF A SAIL. The clues or lower corners of a ship's main-sail or fore-sail, when the middle part is furled or tied up to the yard.

GRIPING. The inclination of a ship to run to windward of her proper course.

GROUNDING. The laying a ship a-shore, in order to repair her. It is also applied to running a-ground accidentally.

GROUND-TACKLE. Every thing belonging to a ship's anchors, and which are necessary for anchoring or mooring; such as cables, hawsers, tow-lines, warps, buoy-ropes, &c.

GROWING. Stretching out; applied to the direction of the cable from the ship towards the anchors; as, the cable **GROWS** on the starboard bow.

GYBING.

GYBING. The act of shifting any boom-sail from one side of the mast to the other.

TO HAIL. To salute or speak to a ship at a distance.

TO HAND, THE SAILS. The same as to FURL them.

HAND-OVER-HAND. The pulling of any rope, by the men's passing their hands alternately one before the other or one above another. A sailor is said to go aloft **HAND-OVER-HAND** when he climbs into the tops by a single rope, dexterously throwing one hand over the other.

HANDSOMELY. Gradually, as **LOWER HANDSOMELY.**

HANK-FOR-HANK. When two ships tack and make a progress to windward together.

HARD A-LEE. The situation of the helm, when pushed close to the lee side of the ship.

HARD A-WEATHER. The situation of the helm, when pushed close to the weather side of the ship.

TO HAUL. To pull a single rope without the assistance of blocks.

TO HAUL THE WIND. To direct the ship's course nearer to the point from which the wind blows.

Thus the ship A hauls the wind, when, by the trim of her sails and the action of her rudder, she gets on either of the courses B and C.



HAWSE. The situation of the cables before the ship's stem, when she is moored with two anchors out from forward. It also denotes any small distance a-head of a ship, or the space between her head and the anchors employed to ride her.

HEAD-FAST. A rope employed to confine the head of a ship to a wharf or to some other ship.

HEADMOST. The situation of any ship or ships which are the most advanced in a fleet.

HEAD-SAILS. All the sails which belong to the fore-mast and bowsprit.

HEAD-SEA. When the waves meet the head of a ship in her course, they are called a **HEAD-SEA**. It is likewise applied to a large single wave coming in that direction.

HEAD-

BING.

HEAD-TO-WIND. The situation of a ship when her head is turned to the point from which the wind blows, as it must when tacking.

HEAD-WAY. The motion of advancing, used in opposition to **STERN-WAY**.

To HEAVE. To turn about a capstern, or other machine of the like kind, by means of bars, handspecks, &c.

To HEAVE A-HEAD. To advance the ship by heaving-in the cable or other rope fastened to an anchor at some distance before her.

To HEAVE A-PEEK. To heave-in the cable, till the anchor is a-peek.

To HEAVE A-STERN. To move a ship backwards by an operation similar to that of **HEAVING A-HEAD**.

To HEAVE DOWN. **To CAREEN.**

To HEAVE-IN THE CABLE. To draw the cable into the ship, by turning the capstern.

To HEAVE IN STAYS. To bring a ship's head to the wind, by a management of the sails and rudder, in order to get on the other tack.

To HEAVE OUT. To unfurl or loose a sail; more particularly applied to the stayfairs: thus we say, loose the topfairs and **HEAVE OUT** the stayfairs.

To HEAVE SHORT. To draw so much of the cable into the ship, as that she will be almost perpendicularly over her anchor.

To HEAVE TIGHT or TAUGHT. To turn the capstern round, till the rope or cable becomes straitened.

To HEAVE THE CAPSTERN. To turn it round.

To HEAVE THE LEAD. To throw the lead overboard, in order to find the depth of water.

To HEAVE THE LOG. To throw the log overboard, in order to calculate the velocity of the ship's way.

To HEEL. To stoop or incline to one side; thus they say **TO HEEL TO PORT**, that is to heel to the larboard side.

HELM A-LEE! A direction to put the helm over to the lee side.

HELM A-WEATHER! An order to put the helm over to the windward side.

HIGH-

HIGH-AND-DRY. The situation of a ship when so far run a-ground as to be seen dry upon the strand.

To HOIST. To draw up any body by the assistance of one or more tackles. Pulling by means of a single block is never termed **HOISTING**, except only the drawing of the sails upwards along the masts or stays.

To HOLD ITS OWN is applied to the relative situation of two ships when neither advances upon the other; each is then said to **HOLD ITS OWN**. It is likewise said of a ship which, by means of contrary winds, cannot make a progress towards her destined port, but which however keeps nearly the distance she had already run.

To HOLD ON. To pull back or retain any quantity of rope acquired by the effort of a capstern, windlass, tackle, block, &c.

HOME implies the proper situation of any object; as, to haul **HOME** the top-sail-sheets is to extend the bottom of the top-sail to the lower yard, by means of the sheets. In stowing a hold, a cask, &c. is said to be **HOME**, when it lies close to some other object.

To HULL A SHIP. To fire cannon-balls into her hull within the point-blank range.

HULL-TO. The situation of a ship when she lies with all her sails furled; as in **TRYING**.

IN STAYS. See to **HEAVE** in stays.

KECKLED. Any part of a cable, covered over with old ropes, to prevent its surface from rubbing against the ship's bow or fore foot.

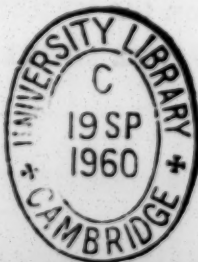
To KEEP AWAY. To alter the ship's course to one rather more large, for a little time, to avoid some ship, danger, &c. **KEEP AWAY** is likewise said to the steersman, who is apt to go to windward of the ship's course.

To KEEP FULL. To keep the sails distended by the wind.

To KEEP HOLD OF THE LAND. To steer near to or in sight of the land.

To KEEP OFF. To sail off or keep at a distance from the shore.

D



To

TO KEEP THE LAND ABOARD. The same as **TO KEEP HOLD OF THE LAND.**

TO KEEP THE LUFF. To continue close to the wind.

TO KEEP THE WIND. The same as **TO KEEP THE LUFF.**

KNOT. A division of the log-line, answering, in the calculation of the ship's velocity, to one mile.

TO LABOUR. To roll or pitch heavily in a turbulent sea.

LADEN IN BULK. Freightened with a cargo not packed, but lying loose, as corn, salt, &c.

LAIID-UP. The situation of a ship when moored in a harbour, for want of employ.

LAND-FALL. The first land discovered after a sea-voyage. Thus a **GOOD LAND-FALL** implies the land expected or desired; a **BAD LAND-FALL** the reverse.

LAND-LOCKED. The situation of a ship surrounded with land, so as to exclude the prospect of the sea, unless over some intervening land.

LARBOARD. The left side of a ship, looking towards the head.

LARBOARD-TACK. The situation of a ship when sailing with the wind blowing upon her larboard side.

LAYING THE LAND. A ship which increases her distance from the coast, so as to make it appear lower and smaller, is said to **LAY THE LAND.**

LEADING-WIND. A fair wind for a ship's course.

LEAK. A chink or breach in the sides or bottom of a ship, through which the water enters into the hull.

To LEAK. To admit water into the hull through chinks or breaches in the sides or bottom.

LEE. That part of the hemisphere to which the wind is directed, to distinguish it from the other part which is called to windward.

LEE-GAGE. A ship or fleet to leeward of another is said to have the lee-gage.

LEE-LURCHES. The sudden and violent rolls which a ship often takes to leeward, in a high sea; particularly when a large wave strikes her on the weather side.

LEE OF THE SHORE. See **UNDER THE LEE OF THE SHORE.**

LEE-

LEE-QUARTER. That quarter of a ship which is on the lee-side.

LEE-SHORE. That shore upon which the wind blows.

LEE-SIDE. That half of a ship lengthwise, which lies between a line drawn through the middle of her length and the side which is farthest from the point of wind.

To LEEWARD. Towards that part of the horizon to which the wind blows.

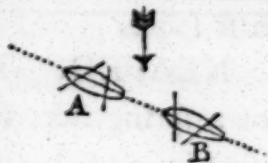
LEEWARD SHIP. A ship that falls much to leeward of her course, when sailing close-hauled.

LEEWARD TIDE. A tide that sets to leeward.

LEE-WAY. The lateral movement of a ship to leeward of her course; or the angle which the line of her way makes with a line in the direction of her keel.

To LIE ALONG. To be pressed down sideways by a weight of sail in a fresh wind.

To LIE-TO. To retard a ship in her course, by arranging the sails in such a manner as to counteract each other with nearly an equal effort, and render the ship almost immovable, with respect to her progressive motion or headway. Thus the position of the yards, in the figures A and B, causes the sails to counteract each other, the wind blowing upon the after-surface of one and the fore-surface of the other.



A LONG SEA. An uniform motion of long waves.

LOOK-OUT. A watchful attention to some important object or event that is expected to arise. Thus persons on board of a ship are occasionally stationed to LOOK OUT for signals, other ships, for land, &c.

To LOOSE. To unfurl or cast loose any sail.

To LOWER. To ease down gradually.

LUFF! The order to the steersman to put the helm towards the lee-side of the ship, in order to sail nearer to the wind.

To MAKE A BOARD. To run a certain distance upon one tack, in beating to windward.

To MAKE FOUL WATER. To muddy the water, by running in shallow places, so that the ship's keel disturbs the mud at bottom.

To MAKE SAIL. To increase the quantity of sail already set, either by unreefing or by setting others.

To MAKE STERNWAY. To retreat or move with the stern foremost.

To MAKE THE LAND. To discover it from afar.

To MAKE WATER. To leak.

To MAN THE YARD, &c. To place men on the yard, in the tops, down the ladder, &c. to execute any necessary duties.

MASTED. Having all her masts complete.

To MIDDLE A ROPE. To double it into two equal parts.

MIDSHIPS. See **AMIDSHIPS**.

To MISS STAYS. A ship is said to **MISS STAYS**, when her head will not fly up into the direction of the wind, in order to get her on the other tack.

MOORING. Securing a ship in a particular station by chains or cables, which are either fastened to an adjacent shore or to anchors at the bottom.

MOORING SERVICE. When a ship is moored, and rides at one cable's length, the mooring service is that which is at the first splice.

NEAPED. The situation of a ship left a-ground on the height of a spring tide, so that she cannot be floated till the return of the next spring tide.

NEAR or NO NEAR. An order to the steersman not to keep the ship so close to the wind.

OFF-AND-ON. When a ship is beating to windward, so that by one board she approaches towards the shore, and by the other stands out to sea, she is said to stand **OFF-AND-ON** shore.

OFFING. Out at sea, or at a competent distance from the shore, and generally out of anchor-ground.

OFFWARD. From the shore; as when a ship lies a-ground and leans towards the sea, she is said to heel **OFFWARD**.

ON THE BEAM. Any distance from the ship on a line with the beams, or at right angles with the keel. See **BEARING**.

ON THE BOW. An arch of the horizon, comprehending about four points of the compass on each side of that point to which the ship's head is directed. Thus, they say, the ship in sight bears
three

three points **ON THE STARBOARD-BOW**; that is three points, towards the right-hand, from that part of the horizon which is right a-head. See **BEARING**.

ON THE QUARTER. An arch of the horizon, comprehending about four points of the compass on each side of that point to which the ship's stern is directed. See **ON THE BOW** and **BEARING**.

OPEN. The situation of a place exposed to the wind and sea. It is also expressed of any distant object to which the sight or passage is not intercepted.

OPEN HAWSE. When the cables of a ship at her moorings lead strait to their respective anchors, without crossing, she is said to ride with an **OPEN HAWSE**.

OVER-BOARD. Out of the ship.

OVER-GROWN SEA is expressed of the ocean when the surges and billows rise extremely high.

To OVER-HAUL. To open and extend the several parts of a tackle, or other assemblage of ropes, thereby fitting them the better for running easily.

OVER-RAKE. When a ship at anchor is exposed to a head-sea, the waves of which break in upon her, the waves are said to **OVER-RAKE** her.

OVER-SET. A ship is **OVER-SET**, when her keel turns upwards.

OUT-OF-TRIM. The state of a ship, when she is not properly balanced for the purposes of navigation.

PARLIAMENT-HEEL. The situation of a ship when she is made to stoop a little to one side, so as to clean the upper part of her bottom on the other side. See **BOOT-TOPPING**.

PARTING. Being driven from the anchors, by the breaking of the cable.

To PAWL THE CAPSTERN. To fix the pawls, so as to prevent the capstern from recoiling, during any pause of heaving.

To PAY. To daub or cover the surface of any body with pitch, tar, &c. in order to prevent it from the injuries of the weather.

To PAY AWAY or **PAY OUT**. To slacken a cable or other rope, so as to let it run out for some particular purpose.

To

To PAY OFF. To move a ship's head to leeward.

To PEEK THE MIZEN. To put the mizen-yard perpendicular by the mast.

PITCHING. The movement of a ship, by which she plunges her head and after-part alternately into the hollow of the sea.

To PLY TO WINDWARD. To endeavour to make a progress against the direction of the wind. See **BEATING TO WINDWARD.**

POINT-BLANK. The direction of a gun when levelled horizontally.

POOPING. The shock of a high and heavy sea upon the stern or quarter of a ship, when she scuds before the wind in a tempest.

PORT. A name given on some occasions to the larboard side of the ship; as, the ship heels to port, top the yards to port, &c.

PORT THE HELM! The order to put the helm over to the larboard side.

PORT-LAST. The gunwale.

PORTOISE. The same as **PORT-LAST**; **TO RIDE A PORTOISE** is to ride with a yard struck down to the deck.

PRESS OF SAIL. All the sail a ship can set or carry.

PRIZING. The application of a lever to move any weighty body.

PURCHASE. Any sort of mechanical power employed in raising or removing heavy bodies.

QUARTERS. The several stations of a ship's crew in time of action.

QUARTERING. When a ship under sail has the wind blowing on her quarter.

To RAISE. To elevate any distant object at sea by approaching it; thus, **TO RAISE THE LAND** is used in opposition to **LAY THE LAND.**

To RAKE. To cannonade a ship at the stern or head, so that the balls scour the whole length of the decks.

RANGE

RANGE OF CABLE. A sufficient length of cable drawn upon deck before the anchor is cast loose, to admit of its sinking to the bottom without any check.

REACH. The distance between any two points on the banks of a river, wherein the current flows in an uninterrupted course.

READY ABOUT! A command of the boatswain to the crew, and implies that all the hands are to be attentive and at their stations for tacking.

REAR. The last division of a squadron, or the last squadron of a fleet. It is applied likewise to the last ship of a line, squadron, or division.

REEF. Part of a sail from one row of eyelet-holes to another. It is applied likewise to a chain of rocks lying near the surface of the water.

REEFING. The operation of reducing a sail by taking in one or more of the reefs.

To REEVE. To pass the end of a rope through any hole, as the channel of a block, the cavity of a thimble, &c.

RENDERING. The giving way or yielding to the efforts of some mechanical power. It is used in opposition to jamming or sticking.

RIDING, when expressed of a ship, is the state of being retained in a particular station by an anchor and cable. Thus she is said to **RIDE EASY** or to **RIDE HARD**, in proportion to the strain upon her cable. She is likewise said to **RIDE LEEWARD TIDE** if anchored in a place at a time when the tide sets to leeward, and to **RIDE WINDWARD TIDE** if the tide sets to windward: to **RIDE BETWEEN WIND AND TIDE**, when the wind and tide are in direct opposition, causing her to ride without any strain upon her cables.

RIGHTING. Restoring a ship to an upright position, either after she has been laid on a careen, or after she has been pressed down on her side by the wind.

To RIGHT THE HELM is to bring it into midships, after it has been pushed either to starboard or larboard.

RIGGING

RIGGING OUT A BOOM. The running out a pole at the end of a yard to extend the foot of a sail.

TO RIG THE CAPSTERN. To fix the bars in their respective holes.

ROLLING. The motion by which a ship rocks from side to side like a cradle.

ROUGH-TREE. A name applied to any mast, yard, or boom, placed in merchant-ships, as a rail or fence above the vessel's side, from the quarter-deck to the fore-castle.

ROUNDING-IN. The pulling upon any rope which passes through one or more blocks in a direction nearly horizontal; as, **ROUND-IN** the weather-braces.

ROUND-TURN. The situation of the two cables of a ship when moored, after they have been several times crossed by the swinging of the ship.

ROUNDING-UP. Similar to **ROUNDING-IN**, except that it is applied to ropes and blocks which act in a perpendicular direction.

TO ROW. To move a boat with oars.

ROWSING. Pulling upon a cable or rope without the assistance of tackles.

TO RUN OUT A WARP. To carry the end of a rope out from a ship in a boat, and fastening it to some distant object, so that by it the ship may be removed by pulling on it.

TO SAG TO LEEWARD. To make considerable lee-way

SAILING-TRIM is expressed of a ship when in the best state for sailing.

SCANTING. The variation of the wind, by which it becomes unfavourable to a ship's making great progress, as it deviates from being large, and obliges the vessel to steer close-hauled or nearly so.

SCUDDING. The movement by which a ship is carried precipitately before the wind in a tempest.

SCUTTLING. Cutting large holes through the bottom or sides of a ship, either to sink her or to unlade her expeditiously when stranded.

SEA.

SEA. A large wave is so called. Thus they say, a **HEAVY SEA**. It implies likewise the agitation of the ocean, as, a **GREAT SEA**. It expresses the direction of the waves, as, a **HEAD SEA**. A **LONG SEA** means an uniform and steady motion of long and extensive waves; a **SHORT SEA**, on the contrary, is when they run irregularly, broken, and interrupted.

SEA-BOAT. A vessel that bears the sea firmly, without straining her masts, &c.

SEA-CLOTHES. Jackets, trowsers, &c.

SEA-MARK. A point or object on shore conspicuously seen at sea.

SEA-ROOM. A sufficient distance from the coast or any dangerous rocks, &c. so that a ship may perform all nautical operations without danger of shipwreck.

SENDING. The act of pitching precipitately into the hollow between two waves.

SETTING. The act of observing the situation of any distant object by the compass.

To SET SAIL. To unfurl and expand the sails to the wind, in order to give motion to the ship.

To SET UP. To increase the tension of the shrouds, backstays, &c. by tackles, laniards, &c.

To SETTLE THE LAND. To lower in appearance. It is synonymous with **TO LAY THE LAND**.

To SHAPE A COURSE. To direct or appoint the track of a ship in order to prosecute a voyage.

SHEERING. The act of deviating from the line of the course, either to the right or left.

To SHEER OFF. To remove to a greater distance.

To SHEET-HOME. To haul the sheets of a sail home to the block on the yard-arm.

To SHIFT THE HELM. To alter its position from right to left, or from left to right.

To SHIP. To take any person, goods, or thing, on board. It also implies to fix any thing in its proper place; as, to **SHIP THE OARS**, to fix them in their rowlocks.

E

SHIVERING.

SEA.

SHIVERING. The state of a sail when fluttering in the wind.

SHOAL. Shallow.

To SHOE THE ANCHOR. To cover the flukes with a piece of plank to give it firmer hold in soft ground.

To SHOOT A-HEAD. To advance forward.

SHORE. A general name for the sea-coast of any country.

To SHORTEN SAIL. Used in opposition to **MAKE SAIL**.

SLACK-WATER. The interval between the flux and reflux of the tide, when no motion is perceptible in the water.

SLATCH is applied to the period of a transitory breeze.

To SLIP THE CABLE. To let it run quite out when there is not time to weigh the anchor.

To SLUE. To turn any cylindrical piece of timber about its axis without removing it. Thus, to **SLUE A MAST** or **BOOM** is to turn it in its cap or boom-iron.

SOUNDING. Trying the depth of the water with a plummet, sunk from a ship to the bottom.

To SPELL THE MIZEN. To let go the sheet and peek it up.

To SPILL. To discharge the wind out of the cavity or belly of a sail, when it is drawn up in the brails, in order to furl or reef it.

SPLIT. The state of a sail rent by the violence of the wind.

SPOON-DRIFT. A sort of showery sprinkling of the sea-water, swept from the surface of the waves in a tempest, and flying like a vapour before the wind.

SPRAY. The sprinkling of a sea, driven occasionally from the top of a wave, and not continual as **SPOON-DRIFT**.

To SPRING A MAST, YARD, &c. To crack a mast, yard, &c. by means of straining in blowing weather, so that it is rendered unsafe for use.

To SPRING A LEAK. When a leak first commences, a ship is said to **SPRING A LEAK**.

To SPRING THE LUFF. A ship is said to **SPRING HER LUFF** when she yields to the effort of the helm, by failing nearer to the wind than before.

SQUALL.

SQUALL. A sudden violent blast of wind.

SQUARE. This term is applied to yards that are very long, as **TAUNT** is to high masts.

To SQUARE THE YARDS. To brace the yards, so as to hang at right angles with the keel.

To STAND ON. To continue advancing.

To STAND IN. To advance towards the shore.

To STAND OFF. To recede from the shore.

STARBOARD. The right-hand side of the ship, when looking forward.

STARBOARD-TACK. A ship is said to be on the **STARBOARD-TACK**, when sailing with the wind blowing upon her starboard-side.

STARBOARD THE HELM! An order to push the helm to the starboard-side.

To STAY A SHIP. To arrange the sails and move the rudder, so as to bring the ship's head to the direction of the wind, in order to get her on the other tack.

STEADY! The order to the helmsman to keep the ship in the direction she is going at that instant.

STEERING. The art of directing the ship's way by the movement of the helm.

STEERAGE-WAY. Such degree of progressive motion of a ship as will give effect to the motions of the helm.

To STEM THE TIDE. When a ship is sailing against the tide at such a rate as enables her to overcome its power, she is said to **STEM THE TIDE**.

STERNFAST. A rope confining a ship by her stern to any other ship or wharf.

STERNMOST. The farthest a-stern, opposed to **HEAD-MOST**.

STERNWAY. The motion by which a ship falls back with her stern foremost.

STIFF. The condition of a ship when she will carry a great quantity of sail without hazard of oversetting. It is used in opposition to **CRANK**.

To STOW. To arrange and dispose a ship's cargo.

To STREAM THE BUOY. To let it fall from the ship's side into the water, previously to casting anchor.

To STRIKE. To lower or let down any thing. Used emphatically to denote the lowering of colours in token of surrender to a victorious enemy.

To STRIKE SOUNDING. To touch ground, when endeavouring to find the depth of water.

SURF. The swell of the sea that breaks upon shore or on any rock.

To SURGE THE CAPSTERN. To slacken the rope heaved round upon it.

SWELL. The fluctuating motion of the sea either during or after a storm.

SWEEPING. The act of dragging the bight or loose part of a rope along the surface of the ground, in a harbour or road, in order to drag up something lost.

SWINGING. The act of a ship's turning round her anchor at the change of wind or tide.

To TACK. To turn a ship about from one tack to another, by bringing her head to the wind. Thus the ship A passes from the larboard to the starboard tack a.



TAKING-IN. The act of furling the sails. Used in opposition to **SETTING**.

TAKEN A-BACK. See **A-BACK**.

TAUGHT. Improperly though very generally used for **TIGHT**.

TAUNT. High or tall. Particularly applied to masts of extraordinary length.

TENDING. The turning or swinging of a ship round her anchor in a tide-way at the beginning of ebb and flood.

THWART. See **A-THWART**.

THWART SHIPS. See **A-THWART SHIPS**.

THUS! An order to the helmsman to keep the ship in her present situation, when sailing with a scant wind.

TIDE-

TIDE-WAY. That part of a river in which the tide ebbs and flows strongly.

TIER. One range of any thing placed horizontally.

TOPPING. Pulling one of the ends of a yard higher than the other.

To TOW. To draw a ship in the water by a rope fixed to a boat or other ship which is rowing or sailing on.

TRIM. The state or disposition by which a ship is best calculated for the purposes of navigation.

To TRIM THE HOLD. To arrange the cargo regularly.

To TRIM THE SAILS. To dispose the sails in the best arrangement for the course which a ship is steering.

To TRIP THE ANCHOR. To loosen the anchor from the ground, either by design or accident.

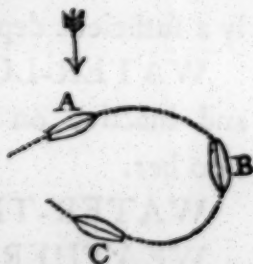
TROUGH OF THE SEA. The hollow between two waves.

TRYING. The situation in which a ship, in a tempest, lies to in the trough or hollow of the sea, particularly when the wind blows contrary to her course.

TURNING TO WINDWARD. That operation in sailing, whereby a ship endeavours to advance against the wind.

VAN. The foremost division of a fleet in one line. It is likewise applied to the foremost ship of a division.

To VEER. To change a ship's course, from one tack to the other, by turning her stern to windward: thus the ship A veers, in passing from the course A to the course C. The wind is said to veer when it changes more aft.



To VEER AND HAUL. To pull a rope tight, by alternately drawing it in and slackening it.

To UNBALLAST. To discharge the ballast out of a ship.

To UNBEND. To take the sails off from their yards and stays. To cast loose the anchor from the cable. To untie two ropes.

To UNBIT. To remove the turns of a cable from off the bits.

UNDER FOOT is expressed of an anchor that is directly under the ship.

UNDER

UNDER SAIL. When a ship is loosened from moorings, and is under the government of her sails and rudder.

UNDER WAY. The same as **UNDER SAIL**.

UNDER THE LEE OF THE SHORE is to be close under the shore which lies to windward of the ship.

To UNMOOR. To reduce a ship to the state of riding at single anchor, after she has been moored.

To UNREEVE. To draw a rope from out of a block, thimble, &c.

To UNRIG. To deprive the ship of her rigging.

WAKE. The print or track impressed upon the surface of the water by a ship in her course. A ship is said to be **IN THE WAKE** of another, when she follows her in the same track, or on a line supposed to be formed on a continuation of her keel. Thus the ship A is sailing in the wake of B, and the ship C is crossing in the wake of A and B.



To WARE. See **TO VEER**.

WARP. A small rope employed occasionally to remove a ship from one place to another.

To WARP. To remove a ship by means of a warp.

WATER-BORNE. The state of a ship, when there is barely a sufficient depth of water to float her off from the ground.

WATER-LOGGED. The state of a ship, become heavy and inactive on the sea, from the great quantity of water leaked into her.

WATER-TIGHT. The state of a ship when not leaky.

WEATHER. Synonymous with **WINDWARD**.

WEATHER-BEATEN. Shattered by a storm.

WEATHER-BIT. A turn of the cable about the end of the windlafs.

WEATHER-GAGE. When a ship or fleet is to windward of another she is said to have the **WEATHER-GAGE** of her.

WEATHER-QUARTER. That quarter of the ship which is on the windward side.

WEATHER-SIDE. The side upon which the wind blows.

To

To WEIGH ANCHOR. To heave up an anchor from the bottom.

To WIND A SHIP. To change her position, bringing her head where her stern was.

WIND-ROAD. When a ship is at anchor, and the wind, being against the tide, is so strong as to overcome its power and keep the ship to leeward of her anchor, she is said to be WIND-ROAD.

WIND's EYE. The point from which the wind blows.

To WINDWARD. Towards that part of the horizon from which the wind blows.

WINDWARD-TIDE. A tide that sets to windward.

To WORK A SHIP. To direct the movements of a ship, by adapting the sails and managing the rudder according to the course the ship has to make.

To WORK TO WINDWARD. To make a progress against the direction of the wind.

YAWING. The motion of a ship, when she deviates from her course to the right or left.



TO THE POINT OF VIEW. The point of view is the point from which the

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THE THEORY OF WORKING SHIPS.

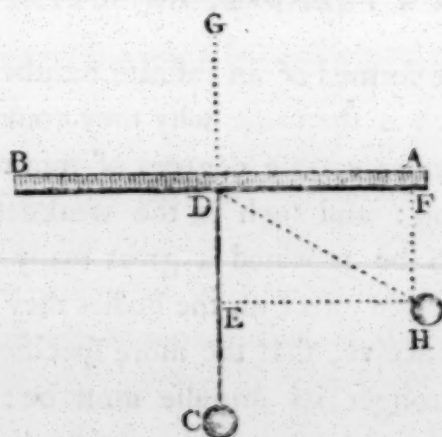
THE theory of working ships is nothing but the demonstration, supported with proofs, of the effects of every sail, and of the rudder, separately or altogether considered, both with respect to the points where these machines are placed in the ship, and with respect to the different dispositions which either are given them in the changes of evolutions, or which arise from their various obliquities, when they present, more or less obliquely, their surfaces to the course of the water or the wind.

L E M M A.

I. IF A BODY STRIKES A SURFACE, IT COMMUNICATES TO IT ALL ITS PERPENDICULAR MOTION.

DEMONSTRATION.

FIGURE 1.



If the body c meets the surface A B, with a motion perpendicular to its middle, or centre of gravity D, it will do it with

with the strength of all its perpendicular motion, which is the produce of its weight by its velocity; and will force it in the direction $D G$, perpendicular to $A B$. If the same body meets the same surface obliquely, and with the same velocity, it will impel it in the direction $D G$, with the velocity only of $D E$, which is equal to the angle of incidence $H F$. For, $H F$ expresses the perpendicular velocity of the body H , towards the surface: and this is evident, if we consider that the movement $H D$ is composed of the two movements $H F$ and $H E$; and that there is no other movement but $H F$ only which can meet the surface $A B$, since the other $H E$ is parallel to it.

But the part $H F$, of the motion of the body H , is perpendicular to the surface $A B$: whence it follows, that the body H impels, in the like perpendicular manner, that surface in the direction $D G$, with a force equal to the product of its weight by the velocity $H F$.

CHAPTER I.

OF THE ACTION WHICH WATER OR WIND HAVE, BY THEIR PRESSURE, ON SURFACES.

2. FLUIDS are formed of an infinite number of particles, the minuteness of which is the cause why they communicate, by their shock, but very imperceptible degrees of motion, in the first instant of their action: and such is the weakness of their action, that it requires to be repeated a great many times before they can produce any sensible effect on the bodies they are to move.

It is easy to conceive, that the more specific gravity a body is possessed of, the stronger its impulse must be: therefore water, which weighs nearly eight hundred and fifty times more than air, ought to produce (the velocity being the same) an impulsion eight hundred and fifty times more than air would against a surface of
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the same size, moved in directions perfectly similar. And when it is known that the impulse of a fluid depends on its specific gravity, it will be easily understood that such an impulse must depend also on the extent of the surface which is struck. For, it is plain that the greater the surface is, (the gravity, the velocity, and the direction, of the fluid being the same,) the stronger the impulse will be, admitting still the same proportion to be kept between the extent of that fluid's surface and that of any other surface put in comparison with it; because a surface of twelve feet square will always receive twelve times as much impulsion as would a surface of only one foot square. We must observe here, at the same time, that such parts of the fluid as strike find more or less difficulty to recoil after the shock, according as the surface is more or less extensive; because, the greater the surface struck, the longer is the continuance of repulsion from their former directions impressed on the particles, which, by that very act of repulsion, receive a new direction, by which they are made to lose for a while the first movement they had during their primitive ones; whence it follows, that the shock of the subsequent particles must be altered: but this deviation from the direct line of the subsequent particles may be looked upon as almost nothing, since there is very little wanting, indeed, but all impulsions should be in the reciprocal proportions which exist between them and the surfaces on which they strike, allowing always all other circumstances to be alike.

3. It must be observed, that the rapidity of the fluid contributes doubly to the force of the impulse; for every particle strikes with so much the more strength as it acts with a greater velocity, and is at the same time followed by a greater number of new particles to shock the surface. So that the greater the celerity of the particles, the greater is the number of those which share the action, and the more powerful is the resistance they oppose to their being put out of their direct motion. But, if the fluid is possessed of five or six times more rapidity, it is evident that every particle enjoys likewise five or six times more force to shock the surface which opposes the passage of them all together; as, on the side of the surface, there are five or six times as many particles to

encounter in the same space of time: therefore such a surface, thus exposed to the shock of the fluid, will be struck with twenty-five or thirty-six times more force at one time than at another, since there are five or six times as many particles employed in the act of striking, and supported with five or six times as much rapidity. Whence it may be concluded, that impulsions increase as the squares of velocities; or, rather, that they are between themselves as the squares of their velocities, when all other circumstances are the same.

When a surface is exposed to the course of a fluid, it is indifferent whether we consider that the fluid shocks the surface, or that the surface moves the fluid: or, again, whether we consider the fluid and the surface as having each their respective share of the velocity with which that surface receives the impulse of the fluid.

4. When the wind has little velocity, its action is observed to be but faint; but, when moving with rapidity, then it becomes capable of producing the greatest effects. This is easy to be conceived; for, if to the action of every particle of air, which is stronger by reason of its increased celerity, be added a greater number of particles striking at the same time, it is evident that its force will increase as the square of its velocity; which has already been demonstrated.

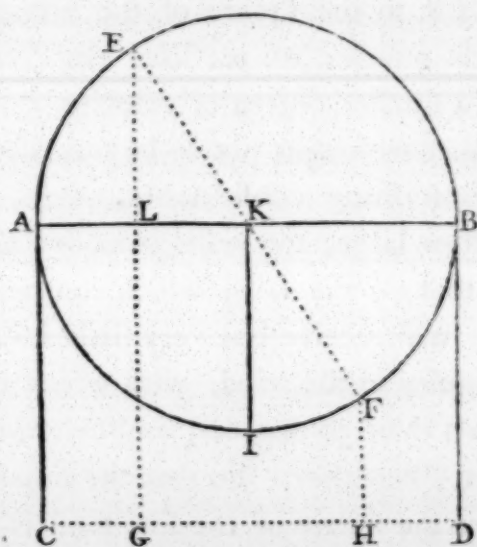
The same may be said of water, the impulse of which is almost like that of a solid when it acts, or is acted upon, with a great rapidity of motion. Whence we must conclude, that if that water meets perpendicularly a body which presents to it a great superficies, such a body must have the greatest solidity to be able to resist it.

5. Experience confirms this principle. For, a ship which drives to leeward does not divide the fluid with her side in a direct line; there is always some obliquity in the direction she pursues by her act of dividing. This obliquity proceeds from the little resistance she experiences from the fluid either at her stem or at her stern. So that, should she be driven ever so little to leeward, she glides always obliquely on the column of water which opposes her under her lee, following a line more or less close to the direction of her length,

length, than to the perpendicular which may be conceived to be drawn as lateral to her keel.

6. We have hitherto spoken of the impulse of fluids upon surfaces only, when considered as perpendicular: but, when that impulse becomes oblique, it is clear, that it must receive a great diminution; since the motion of every particle will be discomposed, on account of its acting only by its motion perpendicular to the surface, as has been demonstrated, (*fig. 1, page 33,*) where the body H may be considered as a particle of a fluid, the impulse of which is proportionably less as the sine of the angle of incidence H D F is diminished: therefore, in this case, when we consider the particle H as a body, its impulse will be in the proportion of the different angles of incidence, which always express their respective velocities, these being considered in a direction perpendicular to the surface.

FIGURE 2.



7. If, instead of one particle, we consider the whole surface as exposed to the course of all those which compose a fluid; it will appear evident, from what has been said, that the surface E F, (*fig. 2,*) which is oblique to the course of the fluid, presents to that fluid a less surface than it would if it were perpendicular to it, like A B. So that each particle produces a less shock, and the particles which

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are at the same time contributing to the shock are less in number. Now, as these two causes of diminution follow the same proportion, it results, that the impulsions of fluids are between themselves as the squares of the sines of incidence. Therefore, as soon as the impulse of a fluid, which strikes a surface perpendicularly, is known, that impulse, when it strikes the surface obliquely, is only to be diminished in the same proportion as the sine total IK is to the square of the sine of incidence LK .

The surface AB (*fig. 2.*) receives all the direct impulse of the fluid which strikes it perpendicularly, and which is contained between CD : but the same surface, presented obliquely to the fluid in the direction EF , will receive but a part of the impulse, which will be proportional to the sine of incidence LK , compared with the sine total IK , of the direct effort of every particle contained between the parallels EG and FH , which inclose a much less space than the first AC and BD . Whence it is easy to conclude, that the diminution of the impulse of the fluid has diminished on two sides, and has consequently followed the proportion of the square of the sine total IK to the square of the sine of incidence LK ; for there is a less number of particles employed in striking the surface, and with a smaller degree of velocity.

8. It follows, that we ought not to be surpris'd to see the velocity of a ship diminishing considerably, when, after having run with the wind aft or large, the vessel is hauled closer to the wind. For it is evident that all the sails, which can possibly be spread in this last direction, will receive but very little impulse, on account of their great obliquity to the wind, with which they cannot make an angle more open than 30 degrees, and sometimes much less, as will be demonstrated hereafter. So that the impulse has diminished in proportion as the square of the sine total is to the sine of incidence of 30 degrees; that is to say, as 4 to 1. Therefore, the sails, receiving but a very faint impulse, can communicate to the ship but a small motion; and that motion is still enfeebled by the resistance of the water on the lee-bow; which resistance increases, on one hand, by the inclination of the ship; and, on the other, by the greater surface which she presents to the water in the direction of her length; to which must be added, the decomposition of the
absolute

absolute effort of the sails, the lateral part of which is now become much greater than the direct. Hence we find the rapidity of the ship's way is already diminished from three evident causes, to which another may still be added; and it is this: If the ship has an inclination to the horizon, (as this always happens in oblique courses, and as we have already hinted,) and if the wind has ever so little force, there will result again from that circumstance a cause of diminution of impulse of the wind on the sails; because, in such a case, the sails follow that particular inclination of the ship called *heeling*; and this diminution of impulse will follow this particular proportion, viz. that in such a direction the square of the sine of incidence will be smaller than that of the sine total. Therefore, we see that the absolute sine of incidence diminishes in a twofold proportion, and receives that diminution from the compound ratio of the proportion which the sine total bears to the two sines of the obliquity of the yard with the wind and of the inclination of the sail with the wind.

9. The impulse of the wind, being continual, must necessarily communicate to the ship degrees of velocity, which, from instant to instant, are increasing, until there happens to be an equilibrium between the impulse of the wind on the sails and the resistance of the water on the bows, observing, that, in the courses where the ship sails with the wind abaft the beam, the first moment when the wind strikes the sails is the time when its impulse is greatest, and the resistance of the water the weakest; because, at that instant, the ship does not yet move in the fluid, not having yielded to the power of the wind: but, in a few moments, the velocity of the ship increasing, the resistance of the water on the bows increases also considerably: then the impulse of the wind on the sails is proportionably decreasing, because, the ship, receding, as it were, from the wind, must of course lessen its power on the sails. Thus the accelerating force is incessantly lessening from two causes; first, from the wind striking the sails with less force; and, second, from the greater part of its impulse being destroyed by the resistance of the water on the bows; a resistance which increases in proportion as the ship's way accelerates; for, this opposition of the water is as a deduction from the effort of the wind; since, by its resistance,

resistance, the water renders part of that effort ineffectual. Therefore, the rate of sailing will be the greatest possible when the impulse of the wind upon the sails shall be so diminished, and the resistance of the water on the bows so increased, as that the two forces, acting in contrary directions, are in a perfect equilibrium. Hence we must conclude, that the vessel will now enjoy a constant and uniform motion; for, the ship advances as if she were not subject to the action of any exterior force, the wind no longer having power to increase her velocity, because the resistance of the water on her bows prevents it; and, on the other hand, the impulse of the wind hinders the water, by its resistance, from retarding her course.

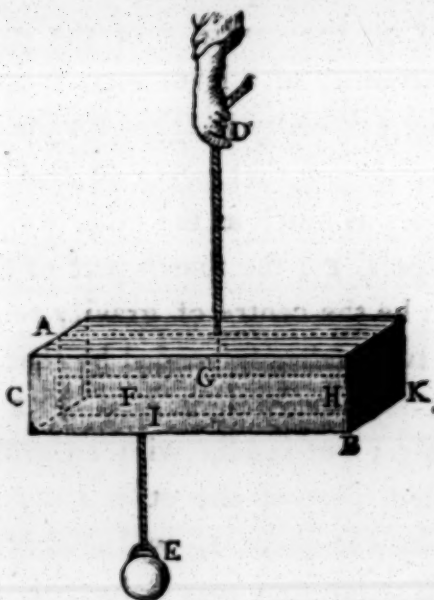
10. If a ship runs on a line perpendicular to the direction of the wind, the impulse on the sails is always the same, because she does not recede from the point from which the wind blows; but, when she sails close-hauled, the impulse must be stronger; because she runs to windward, and draws nearer to that point. So that, if the rate of the ship's sailing be great, the apparent angle of incidence diminishes in proportion to the two velocities, viz. that of the wind and that of the ship.

The moment a surface, which is suspended or afloat, is struck by a fluid, that is the time of the greatest impulsion, (if it were not in motion before,) and of the greatest resistance of the surface.

CHAPTER II.

OF THE CENTRE OF GRAVITY.

FIGURE 3.



11. EVERY solid has a centre of gravity; that is to say, a point, on which, it being suspended, it will have a perfect equilibrium; and on that point all the gravity of the body is united. Such, for example, is the rectangular parallelepipedon A B, (*fig. 3.*) the centre of gravity of which is exactly in the middle of the solid G; so that, if it be suspended from that point, as from G to D, it will always be in equilibrium; because that solid being considered as regular, one of its halves must exactly balance the other; and, were it not regular, the finding of this centre would be much more complicated. Without engaging, therefore, in abstract difficulties, it will be sufficient for our purpose to make it appear, that the centre of gravity of a body, heavier at one extremity than at the other, lies always in the heaviest part, with respect to the point which marks the middle of the length of the body. If, to the solid A B, which is suspended in perfect equilibrium by its centre of gravity G, be added a weight E, in the

G

centre

centre of the part $A G$, the equilibrium will then be lost, as it will increase the weight of this part, which will then overweigh the other half $B G$ by all the weight E , of which the part $B G$ becomes by so much the lighter. To find, then, the centre of gravity, which is changed from G to I , we must divide reciprocally to the weight of the two bodies, $A G + E$ for the one, and $B G$ for the other, the interval $F H$; for, it may be supposed that this half $A + G$ of the parallelepipedon, *plus* the weight E , is a body suspended by the centre F of the part $A G$; and that this point is the extremity of a lever $F H$, infinitely light, which bears also, at the other extremity H , taken for the centre of the other part $B G$, all the weight of that part: so that, if the body $A G + E$ weighs four times as much as the other weight $B G$, we have but to make the interval $F I$ the fourth part of the other $I H$, and the point I will then be the centre of gravity required of the solid $A B + E$, and the two bodies suspended by that point will be in perfect equilibrium; for, the weight $A G + E$ is four times as heavy as the other $B G$; but it acts with an arm of a lever $F I$, which is only a fourth part of the other $I H$; therefore the two weights, suspended by the point I , will preserve a perfect equilibrium in whatever situation they may be placed, as they make, in fact, both but one, the heaviness of which may be supposed united in the single point I .

12. It follows, from what has been demonstrated, that a long lever is productive of a greater effect than a short one, when both are actuated by the same force; whence we must conclude, that the longest lever, or the greatest distance from the *fulcrum*, or point of support, is proportional to the greatest weight.

It is very easy to be convinced of this truth if we make one of the two following proportions; first, thus; the sum of the two weights $A G + E + B G : F H :: B G : F I$; or $:: A G + E : I H$.

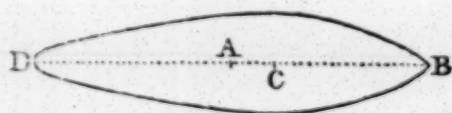
We have supposed that the weight $A G + E$ (*fig. 3*) weighs four times as much as the other $B G$, which I suppose to be two pounds; so that the sum total will be ten pounds. Then say: Ten, the sum of the two weights, is to the whole lever $F H$ as two pounds is to the less part $F I$ of the lever, divided into five equal parts: so that,

if

if FI is equal to two feet, $I H$ will be equal to eight feet, and $F H$ equal to ten feet. But we have also this proportion to make: viz. Ten pound, the sum of the two weights, is to ten feet, the whole length of the lever, as eight pounds are to eight feet; but, admitting the distance $F H$ to be ten feet, the distance FI is found to be two feet, and of $H I$ eight feet; which demonstrates, that a power of two pounds on a lever of eight feet is equal to a power of eight pounds on a lever of two feet; for, the product of the extremes, in both the one and the other proportions, is equal to that of their means.

It ought also to be observed, that the centre of gravity of a solid follows always the greatest weight with respect to the middle G , (*fig. 3*.) since the point I is four times as near the centre F of the heaviest body as it is to the centre H of the lightest body.

FIGURE 4.



13. It follows, that the centre of gravity C of a ship (*fig. 4*) is always before the point A , which is the middle of her absolute length; for, the fore part $B A$, having more capacity than the after part $A D$, must of course have also more weight: therefore it carries the centre of gravity C forward, in proportion to its greater weight, (which in large ships is from fifty to eighty tons,) and to the interval there is between every centre of gravity of each particular part both forward and aft.

14. When a ship is at sea, and loaded, the centre of gravity may well be supposed not to change, unless the cargo be moved.

But it must be observed, that, as experience shows it, the fore or after part of the bottom of a ship plunges and labours more and more, in proportion as the wind acts with more or less force on the sails; because ships are generally not masted according to the *point velique*:* so that a ship, which has the centre of the effort of her

G 2

sails

* From the centre of gravity of the floating line of a ship let a perpendicular be raised, and continued till intersected by the direction of the impulse of the water on the

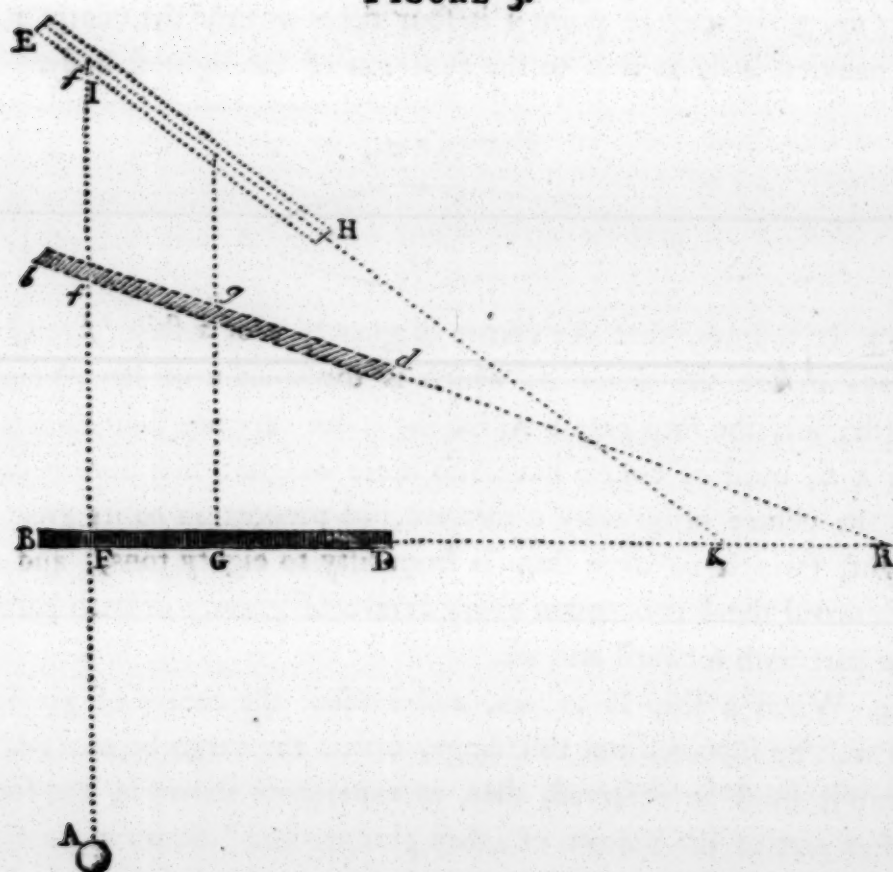
sails ill-placed, draws always more water forward or aft, if the impulse of the wind upon her sails is very powerful, than when she is at ease under her burthen.

THEOREM.

15. The centre of rotation, or the point on which a body turns freely, is always on the other side of the centre of gravity of that body, with respect to the point on which the moving force acts.

DEMONSTRATION.

FIGURE 5.



IF the body BD (*fig. 5*) be struck in its centre of gravity G , when it is perfectly at rest, it is evident (§. 1) that the two extremities B

the bows, in sailing directly before the wind; and, where these two lines cut each other, there is the *point velique*, and where the centre of effort of all the sails should be placed.

and

and D will advance equally on parallels ; but, if it is struck in the point F , distant from the centre of gravity, by any mobile such as A , when the body is subject to no friction, it will then have two motions with respect to its centre of gravity G , on which are collected all the weight and the resistance. For, that centre, not being held by any thing, is moved in the direction Gg , parallel to the direction AI , of the effort of the mobile A , which strikes the body BD in the point F . So that the part BG of that body receives the shock of the mobile A , which makes it pass from F to f , according to the direction of its motion AI . And, as the other part GD of the same body shares that motion only in proportion as its parts are less distant from the point of percussioⁿ F , (since the nearest parts of that point receive the greater share of the action,) in proportion as they remove from their first situation, they all describe, by the first effect of the shock, parallels Bb , Gg , and Dd , to the direction AI of the effort of the mobile A . These parallels are greater as they are more distant from the part shocked and from its extremity B ; because the resistance, which the body BD makes against receiving the motion, cannot be in equilibrium with that which the power A makes to lose part of its own motion, but as much as the two resistances are equal and directly contrary: therefore, the body BD , yielding to the impulse of the mobile A , does not oppose to it a resistance equal to its shock; it must then change its place and situation, in turning on the point R , marked by the meeting of two lines DR and dR , drawn from the centre of gravity of the body BD in those two situations before and after the shock; and, as the circular motion of the body BD is made always round the centre of gravity, it is easy to conceive that the centre, having taken the velocity Gg , must continue to move equally in the same right line prolonged; and that the body, having begun to turn, it must continue to do the same round its centre of gravity, and at the same time be carried in the direction AI on the parallels BE and DH , as long as the force which puts it in motion exists. But it must be remarked, that, in proportion as it shall remove from its first situation BD , it will lose all the relations it had in the principle of motion

motion with the point R ; that is to say, that the point G , being transported to g , in the first instant of the shock, it will continue in the second and the following instants to be thus transported on the same line and in the same direction: therefore the point of rotation R will change in proportion as the body $B D$ removes from the second situation $b d$ to take another $E H$; for, the line $H K$ will cut $D R$ in a point K , nearer the point from which the body was moved; and, although the point of rotation R be continually changing during the time of motion, it remains always on the other side of the centre of gravity with respect to the point of percussion, till at last the body $B D$ be so much turned, that the effort $A I$ may pass through the centre of gravity G in the direction $D B$; then the body $D B$ will cease to turn round a point situated on the part $G D$ prolonged, and will turn successively on different points of the part $G B$, which will then have passed to the opposite side.

16. If the force of the mobile A , (*fig. 5*.) employed to turn the body $B D$, be greater or less, the velocity $G g$ of the centre of gravity will be likewise increased or diminished in proportion as the mobile shall act with more or less power. Consequently, when the body $B D$ changes its situation, the angle it will make with its first position will be proportional to the motion $G g$, or to the force employed in the shock, since they are correspondent to one another. Therefore, all other circumstances being the same, the rapidity of a circular motion will be always in proportion to the force employed to produce it.

17. A method of increasing the rapidity of motion and the angle of rotation is to make the power A (*fig. 5*) act on a point more distant from the centre of gravity G than the given point F ; for, it is clear, that, if the distance $G F$ be two or three times augmented, the other distance $G R$, from the centre of gravity to the point of rotation, will become two or three times less; and the sides of the angle $G R g$, becoming consequently shorter, it follows, that the angle will be more open in the same proportion. Therefore it is demonstrated that there are two sure methods of augmenting both the angle and motion of rotation of a body; the first consists of

of employing more force in the percussion, in order that the angle $G R g$ should be as much increased as is the side $G g$ which subtends it.

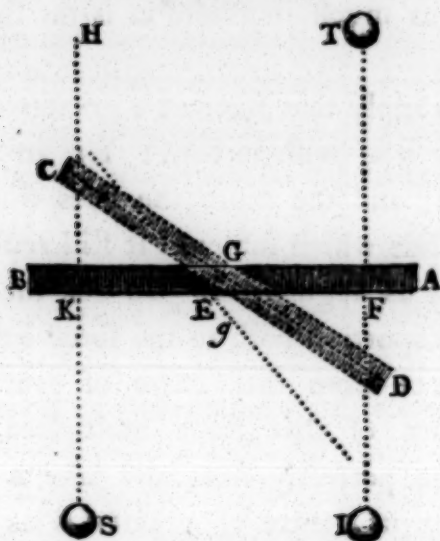
The second is to apply that force at a greater distance from the centre of the body you wish to turn: for, in augmenting $F G$, $G R$ is diminished; and the more the sides which form an angle are shortened, (the side which subtends it still remaining the same,) the more the angle is augmented. So that the angle of rotation is in a compound proportion both to the force employed and to the distance of that force from the centre of gravity: this angle is then as the produce of that force multiplied by $F G$. Although the body be perfectly free, and take a direct motion $G g$, we must consider its centre of gravity G as the point of support, or $F G$ as the arm of a lever; and the angle of rotation $B R b$ is always proportional to the *absolute force** employed in the percussion.

18. Let us consider the body $B D$ (*fig. 5*) exposed to the action of several forces at the same time, and it will appear that the angle of rotation will be proportional to the sum or difference of the absolute forces, according as they tend to turn the body $B D$ in the same or in contrary directions.

If the acting forces directly counteract each other, it is plain that their absolute effect, with respect to the centre of gravity G , must be fought, and then deduct the excess of one from the other: then the angle of rotation will be proportional to that excess; instead of which, it will be proportional to the sum of the forces employed, if they act in concert and in the same manner, to augment it. But if you take no notice of the angle of rotation, and wish to consider the centre of gravity only as being transported from G to g , it is not necessary to find the sum of the absolute forces of the acting powers, but only to consider the forces in themselves, and then $G g$ will be found proportional to either their sum or their difference, according as they contribute to produce the same effect, or as they are opposite in their efforts.

* By the term *absolute force* we understand the force employed to turn the body, multiplied by the distance $F G$, from the centre of gravity.

FIGURE 6.



Suppose these forces equal between themselves but acting in contrary directions on the extremities A and B (*fig. 6*) of the body A B, and on arms of equal levers. Then it is evident, that the angle of rotation is double what it would be if the body were struck by only one of these forces, and turned on its centre of gravity; since the two parts, separated by the centre, are struck equally and at the same time by forces which act perpendicularly in contrary directions. To prove this, observe that the equal powers s and T act at the same time on the body A B with equal levers, G K and G F; so that the extremity B passes to C at the same time that A passes to D; and thereby the centre of gravity G remains as if it were fixed in the same point which serves as a centre of rotation; for, if one of the acting forces removes it from its first situation, the other, in opposing an equal force, will replace it.

If the power T exceeds the other s, it is evident that the centre of gravity G will be transported towards g, in proportion as the force T exceeds the other s; then the body A B could turn no longer on the centre of gravity G, (§. 15,) but on another point E, which would be on the other side of the centre of gravity G, with respect to the point of percussion.

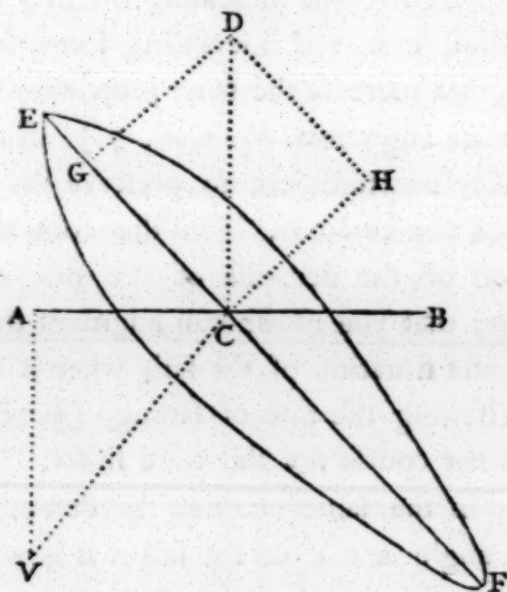
If the body A B (*fig. 6*) were struck at the two points K and F by two mobiles, s and I exerting equal powers with respect to the centre of gravity G; it is plain that the whole body A B will be carried up on parallels, such as I T and s H, and that the sum of the

the two powers will act on the centre of gravity G , since they are equal in every respect.

THEOREM.

19. A SAIL ACTS ALWAYS TWO WAYS ON A SHIP, WHEN IT IS NOT PERPENDICULAR TO HER LENGTH.

FIGURE 7.



DEMONSTRATION.

We have only to consider the sail AB , (*fig. 7.*) oblique to the ship and to the wind, and we must be convinced (§. 1, 7) that it is impelled in the direction CD , with a force expressed by the square of the sine of incidence of the wind upon the sail. Therefore, what we are going to say here for the present case is to be understood as applicable in all others, in which the sail shall not be perpendicular to the length of the ship; for, then, she would go only in the direction of her length from C to E , or from C to F , according as the sail might be full or a-back.

If CD be equal to the impulse of the wind upon the sail, as expressed by the square of the sine of incidence AV , we have only to form the right-angled parallelogram GCH , to be convinced that

H

such

such a direction is composed of the two effects cH and cG , which it produces with respect to the body EF , upon which it acts in impelling it in the direction cD .

The more the yard AB (*fig. 7*) shall make the angle ACE acute, the more the effect cH will augment, and the other cG diminish; for, the more the angle ACE becomes acute, the more its equal $DC H$ or CDG (§. 22) will be acute also; so that cD , which is perpendicular to the centre of the yard, will approach more to cH , the other perpendicular to the length of the ship EF ; which cannot happen without increasing the ship's tendency to fall off in the direction cH , and increasing likewise the cause cD , which follows in that increase the same proportion as the square of the sine of incidence augments. (§. 1, 6, 7.) But this increase of the impulse cD is not sufficient to preserve the effect of the sail in the direction of the keel cG . On the contrary, it diminishes in the proportion of the decrease of the sine ACE or CDG ; whence it follows, that you never can augment the impulse of the wind by shifting the situation of the sail, when it is properly trimmed, without lessening the rate of sailing, (§. 28,) when neither the ship changes her course nor the wind shifts.

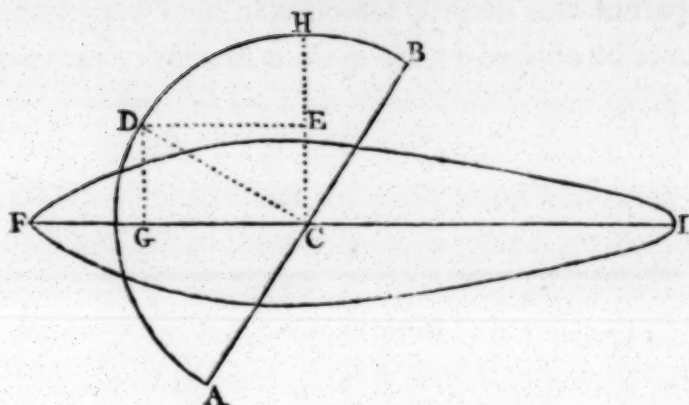
20. It might, in the same manner, be demonstrated, that the more open the angle ACE of the sail AB is with the keel, the more its effect cG , in the direction of the ship's length, will increase in the same proportion as the increase of the sine of that angle, when the impulse of the wind upon the sail is the same; for, the sines of the angles are in proportion to their opposite sides in the triangle CDG , of which the angle CDG is equal to the angle ACE .

If the impulse augment also, (§. 3,) the two effects, cG and cH , will augment proportionally.

21. If the sail AB receive the impulse of the wind E on its forward surface, it would still act in two ways on the ship, by forcing her first a-stern in the direction cF , and then to leeward in the direction Hc : to be convinced of this, reverse the parallelogram, by tracing it on the after part of the yard towards F , and use the same reasoning.

FIGURE

FIGURE 8.



THEOREM.

22. THE ANGLE ACF , (*fig. 8,*) FORMED BY THE YARD AB AND THE KEEL FC OF THE SHIP, IS EQUAL TO THE ANGLE DCH , COMPREHENDED BETWEEN THE PERPENDICULARS DC TO THE YARD AND EC TO THE KEEL, IN THE LIKE MANNER AS THE ANGLE CDG .

DEMONSTRATION.

The angle ACD is right, since CD is perpendicular on AB : the other angle FCE is right also; for CH is perpendicular on FI ; therefore the arc AD is equal to the arc FH ; and if, from these two equal arcs, be taken away the common one FD , the remainders AF and HD will be equal: because, when equals are taken from equals, the remainders must be equal.

Secondly, the angle CDG in the parallelogram GE is alternate to the angle DCE : therefore it is equal to it; therefore it is also equal to ACE .

23. It follows, that the angle BCH is equal to the other angle DCF ; for, if from the two equal arcs AD and BD be taken the other equal arcs FA and DH , the remainders FD and HB will be equal also.

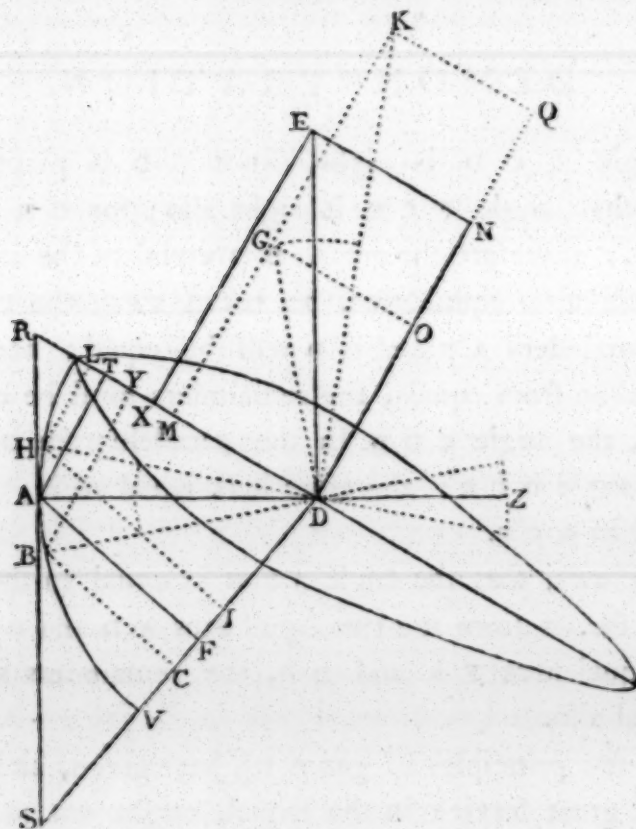
24. The few principles of geometry here given, and which will be found of great service in the sequel, ought not to discourage.

We make use of them now, only to establish principles as simple as they are sure, and to leave nothing to doubt or conjecture in the following part of this theory, which is in itself very abstruse. We shall however be obliged to use again a few more demonstrations of this kind.

CHAPTER III.

OF THE MOST ADVANTAGEOUS ANGLE OF THE SAILS WITH THE KEEL AND THE WIND, IN ORDER TO OBTAIN THE GREATEST RATE OF SAILING ON AN OBLIQUE COURSE.

FIGURE 9.



25. IN most ships the sails make with the keel an angle $A D R$ (*fig. 9*) of 40 degrees, or thereabouts, (some more, some less,) when close-hauled. We are now to undertake to make it appear that this angle is not the most favourable to run with the greatest velocity, in getting to windward. It should be much more oblique; but as it is not possible, in practice, to attain the greatest perfection, we must be contented to approach it as near as possible, in great ships, by reducing the angle $A D R$ to 30 degrees only. This will be so much the more easily done, as in every ship the two foremost shrouds of each lower mast can be suppressed. For it must be observed, that, in the movement of pitching and rolling, the masts always incline forward, in the direction $D E$ of the effort of the sail; so that the shrouds which are abaft, and cat-harpened in, are sufficient to support the masts, since they act nearly opposite to the effort of the sail. Besides, should there be reason to expect bad weather, preventer-shrouds may easily be fastened to the stops which are always ready hung for that purpose. This practice is so much the better grounded, as the number of those preventers can at any time be increased as circumstances or necessity require.*

Therefore, we shall, for the future, consider the angle $A D R$, which is the most oblique in practice, as fixed at 30 degrees, though, in some ships, it may happen to be more acute: a circumstance to which particular attention should be paid.

26. Among the angles $A D R$, $B D R$, and $H D R$, (*fig. 9*), which the sail $A Z$ can make with the keel in the same course $D R$, it is evident there must be one more advantageous than the rest, to produce the greatest velocity possible in the most oblique course. That

* This recommendation of M. Bourdé, to suppress the two foremost shrouds of each lower mast, in order to brace up sharper, we are warranted in saying, cannot be followed in the British navy. It was lately determined, upon a consultation of the officers of the King's Yards, the question having been referred to them, that the present number and dimensions of the rigging of ships could not be advantageously altered or safely diminished. And, as to occasionally casting them off, it may be rendered, by the inevitable accidents of navigation, highly dangerous; as, for instance, in case of being suddenly taken a-back, this lessening of the support of the mast might be attended with its loss.

angle of the fail and the keel is not what we propose directly to determine, since it is impossible to render it more acute than 30 degrees, the term to which we have fixed it in practice: but it will serve us to determine the most favourable angle of incidence AD of the wind upon the fail, and which is the most advantageous to run with the greatest rapidity on all oblique courses between close-hauled and wind abaft.

27. Before we enter upon the demonstration of the rule which must be followed in practice, the principle which serves to demonstrate its utility must be first established. It may be recollected that impulsions (§. 7) are between themselves as the squares of the sines of incidence. Therefore, to judge if it is advantageous to render the angle of incidence AD or ADV of the wind upon the fail AZ more or less acute, we must examine if the square of the sine of incidence AF , or the total impulse DE , increases more or less than the squares of the sines of incidence BC and HI , or than their correspondent impulsions DG and DK , proportionally to the diminution or increase of the sines of the angle of obliquity of the fail with the keel AT , BY , and HL : for, if the square of the sine of incidence HI , or the impulsion DK , does not increase so much proportionally, as the sine of obliquity AT diminishes in becoming equal to LH , it is evident that the position of the fail AD is more favourable than when it is situated in the direction DH : and if the square of the sine of incidence BC , or its correspondent impulsion DG , diminishes more in proportion than the sine AT augments, in becoming equal to the other sine of obliquity BY , in the other position of the fail; it is an evident proof that its situation AD is still more favourable than if it were in the position BD , and that there is even no better situation than AD , whether the angle of incidence ADV be increased or diminished.

28. To prove it, we shall consider (*fig. 9*) the absolute impulsions DK , DE , and DG , as correspondent with the sines of incidence HI , AF , and BC , and proportional to the squares of these same sines; then, on these diagonal lines, if we draw the rectangles xN and MO , in order to dissolve those total impulsions DE and DG , it will appear evident that the direct effort DX , in the direction of the keel, is the greatest possible, when the tangent

As of the angle of incidence is double the tangent AR of the angle of obliquity of the fail with the keel; for, if the angle of incidence be opened ten degrees, by placing the fail in the situation HD , it will appear that, though the total impulsion DK is augmented in the ratio of the square of the new sine of incidence HI to the first AF , the partial effort DM , in the direction of the keel, will be nearly by one-tenth less, in this situation of the fail HD , than in the first AD . The direct impulsions DM , proceeding from the total ones DK and DG , are equal, because these last have augmented or diminished in the same ratio as the sines HL and BY have lessened or increased in proportion to the square of the sine of incidence AF , and to the sine of obliquity AT . These direct partial impulsions DM and DX are in a compounded ratio of the sines of obliquity HL , AT , BY , equal (§. 22) to those of the angles DKM , DEX , DGM , and of the total impulsions DK , DE , and DG ; for, if the total impulsion augment by a movement of the fail, the sine of obliquity diminishes: so that from the total impulsions can at any time be deduced the direct ones for every possible angle of incidence. We might very well verify by calculation this demonstration, which proves that the tangent AS of the angle of incidence must always be double the tangent AR of the angle formed between the fail and the keel, agreeably to the situation of the fail AZ ; since if any other position be given to it with respect to the wind V , whether it be in the direction HD ten degrees more open than AZ , or like BD ten degrees more oblique, a result, as DM , in the direction of the keel, will ever be found less than DX .

As the vanes always indicate the apparent direction of the wind, on all the courses the ship can sail, the angle which the wind makes with the course, or the keel, cannot fail being easily known if there is no lee way; let that angle with the fails be parted into two others, so that the angle of obliquity of the fails with the course may have its tangent equal to half the tangent of the apparent angle of incidence of the wind upon the fails. On this foundation, it will be easy to form a table which will always shew both the apparent angle of incidence, and that of the obliquity of the fail with the keel or with the course. This table will serve

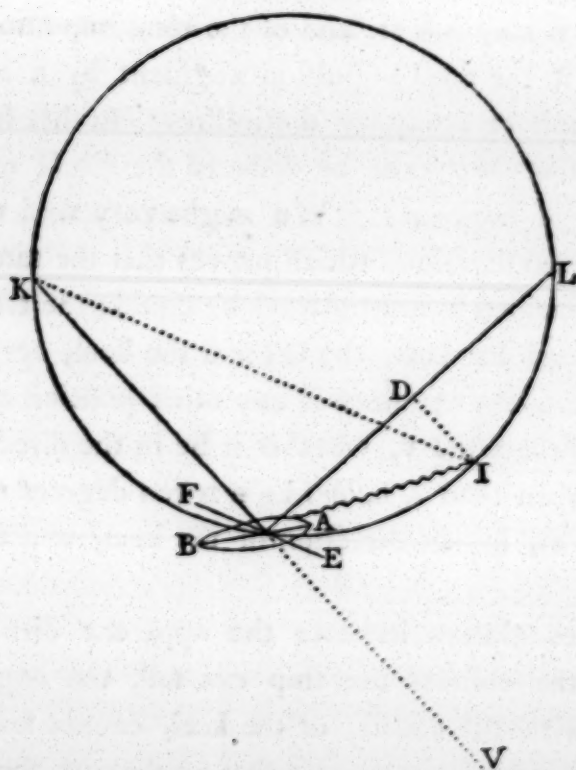
for

for all oblique courses, provided the after fails cover those forward only in a trifling degree; for, should they becalm them much, they must, for other considerations, be braced up a little more to the windward; but always leave the apparent angle of incidence of the wind upon the sail more open than that between the sail and the keel, or the course.

ARTICLE I.

REMARKS ON SAILING BY THE WIND.

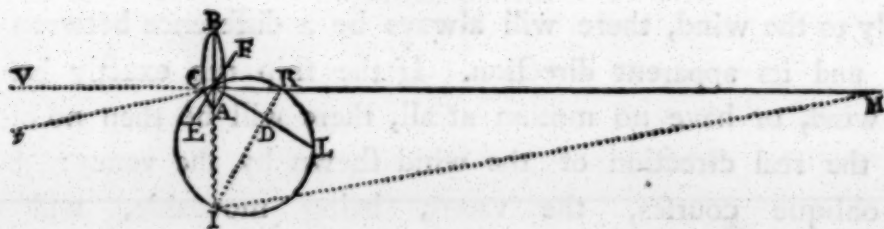
FIGURE 10.



29. When it is desired to gain to windward as much as possible, without absolutely wishing to fail with the greatest velocity, let the direction of the coast under the lee be supposed to make with the absolute direction of the wind (which must as near as possible be known) an angle of 90 degrees; or, in the sea phrase, *blowing dead on shore*: let the angle A C E, (fig. 10,) formed by the sail and the

the keel, be known to be 30 degrees, let the lee-way be also known to be 10 degrees, the angle $E C I$ between the fail and the course will consequently be 40 degrees, which you must take from the total angle $V C L$ 90 degrees; then there will remain 50 degrees, the half of which, 25 degrees, is to be taken for the absolute angle of incidence $V C E$, and for its equal $I C L$; so that the ship $A B$ will go 55 degrees from the wind when she is close-hauled, and will consequently recede as much as possible from the point D on the coast, the direction of which makes an angle of 90 degrees with the absolute direction of the wind $V K$.

FIGURE II.



But, if the situation $C L$, (*fig. II.*) of the point D , from which you wish to move, made an obtuse angle $V C L$, with the positive direction of the wind $V M$; then the tangent of the apparent angle of incidence $V C E$ must be made double the angle of obliquity $E C I$ which the fail makes with the course, at the same time that the angle $I C L$ of the course and the coast shall be made equal to the angle $V C E$, formed by the real direction of the wind $V K$ and of the fail $F E$: so that two considerations must at once be attended to. For example: the angle $A C E$, formed by the fail and the keel, is 30 degrees; then, according to the first principle, it will be necessary that the apparent angle of incidence $V C E$ should be $49^{\circ} 6'$; and if the difference between the apparent and real direction of the wind be 10° , there will be $59^{\circ} 6'$ for the angle which the fail $E F$ makes with the real direction of the wind $V M$: so that the angle $L C I$, of the course and the object stood from, must be found also to be $59^{\circ} 6'$, and the total angle $L C V$ will then be $148^{\circ} 12'$, adhering to the two principles of sailing with the greatest velocity, and of getting to windward of the point D ,

as much as possible, at the same time; while the angle LCV , formed by the apparent direction of the wind and that of the coast from which the ship moves, will be only $138^{\circ} 12'$. The yawing and the different velocities of the ship render the angle formed by the two directions of the wind (the real and the apparent) more or less open. If the ship has more velocity at the same time, or if the course approaches more to the direction of the wind, it will appear by the vanes that the wind draws forward, and the angle of the two directions of the wind will augment. If the ship falls off, and yet still preserves the same velocity, or if her velocity decreases without altering her course, the wind will seem by the vanes to draw aft, and the angle of the two directions will diminish; so that, whenever the ship shall have velocity or run obliquely to the wind, there will always be a difference between its real and its apparent direction. If the ship run exactly before the wind, or have no motion at all, there will be then no other but the real direction of the wind shewn by the vanes: but, in oblique courses, the vanes, being moveable, will fix themselves in a middle direction between the absolute tendency of the wind and the course of the ship; whence we may easily conclude, as we did before, that the apparent direction of the wind, shewn by the vanes, is a medium between the respective velocities of the ship and of the wind; since that direction necessarily partakes more of the greater velocity than of the less: so that, if the ship runs east, with the wind at south, having the fourth part of the velocity of the wind, the vanes will shew S. S. E. $4^{\circ} 30'$ S. for the apparent direction of the wind.

ARTICLE II.

THEOREM OF M. BOUGUER.

The velocity and real direction of the wind is CM ; (*fig. II*;) suppose the ship AB , of which EF is the sail situated at pleasure, to draw the course CI , while the particles of air run in the direction CM : if, from the point I , be drawn IK , parallel to the sail EF , till it cuts the direction of the wind CM , in the point K , there will be given the three points C , I , K , through which draw the circumference of a circle $CI L K$, and that circumference will shew the extent of the forces acting on the ship, at the same time, in following the course CI , provided her sail be always trimmed in the same manner with respect to her keel.

DEMONSTRATION.

The apparent or relative velocity of the wind is represented by IM (*fig. II*) in the course CI ; and as IK is parallel to the sail EF , the angle MIK is equal to the apparent angle of incidence VCE . But to be more explicit: the wind strikes the sail with its apparent or relative velocity IM , (and not with its absolute velocity, because of the motion of the ship,) and with an angle of incidence $MIK = VCE$: so that, if the ship runs close-hauled or perpendicular to the direct wind VC , IM will become in both cases stronger than the absolute velocity; because the ship will either approach to the source of the wind, or not recede from it. But the impulse on the sail is proportional to the square of the velocity IM , multiplied by the square of the sine of the angle of incidence MIK , equal to the angle VCE (§. 3 and 7) and the proportion $MK : \sin KIM :: MI : \sin MKI$, which furnishes us the triangle KIM , shews us that $MK \times \sin MKI = MI \times \sin$

I 2

KIM;

$K I M$; squaring the two products, and substituting the sine of the angle $V K I$ in the room of the sine of the angle $M K I$, which is equal to it, since they are the supplement of each other, we shall then have this other equation: $\overline{\text{sine } V K I}^2 \times \overline{M K}^2 = \overline{\text{sine } K I M}^2 \times \overline{M I}^2$; whence it follows, that instead of expressing the actual impulse of the wind upon the sail by the square of $I M$, multiplied by the square of the sine of the angle $K I M$, it may be expressed by the square of $M K$, multiplied by the square of the sine of the angle $V K I$, or of its equal $V C E$, formed by the absolute direction of the wind $V M$ and the sail $E F$.

We must not forget to be very attentive to this; viz. that the impulse of the wind upon the sails is in equilibrium with the effort of the water on the bows, or that they are exactly equal and contrary when the ship is come to an uniformity of motion (§. 9) as here we suppose her to be. Besides, the impulse of the water on the bows is proportional or equal to the square of the velocity of sailing $C I$, (§. 3,) so that the square of the velocity of sailing $C I$ is equal to the actual impulsion of the wind upon the sail expressed by the square of $K M$, multiplied by the square of the sine of the angle $V C E$; and if s be supposed equal to the sine of $V C E$, or of $V K I$, we shall always find $\overline{C I}^2 = \overline{s}^2 \times \overline{K M}^2$. The first term in this equation represents the impulse of the water on the bows, and the second expresses the effort of the wind upon the sails; and, if the square roots of the one and of the other be taken, it will be found $C I = s \times K M$; that is to say, that the very velocity of sailing $C I$ will be continually equal or proportional to the product of $K M$ by the sine s of the angle $V C E$ or $C K I$. The proportion between these quantities depends on the density of the two fluids, and on the magnitude of the surfaces struck: but it will be the same in all the different courses.

The different velocities of sailing $C I$ have a constant and given proportion with the products $s \times C R$ and $C I \times \text{sine } C I K$; for the triangle $C I K$ gives $s : C I :: \text{sine } C I K : C K$, which forms this equation, $s \times C K = \text{sine } C I K \times C I$; and all the angles C , I , K , are constant and known, since they are equal, being alternate to that which the sail makes with the course. But, as the
velocity

velocity CI bears a continual and constant proportion with the product $s \times KM$, and as it bears also a constant proportion with $s \times CK$, it follows that $s \times KM : s \times CK :: KM : KC$; so that the point K always divides CM in the same proportion: the point K is then invariable when the fail, as well as the lee-way, are both the same; (which never happens, however, as will be made appear (§. 47) hereafter;) but, in admitting these two hypotheses, which never can deviate from the truth but in respect to the lee-way, which is always variable in the same ship, according to the different circumstances of wind, sea, velocity, fail, and course, it ought then to be concluded that all the points, I , &c. will be situated on the circumference of a circle; for, without that, the angles CIK , equal to those which are formed by the course and the fail, and which are supported on the same chord CK , would not be equal.

COROLLARY.

Admitting therefore, (*fig. II, page 57,*) that the velocities are continually proportional to the sines (whatever they be) of the angles VCE , which the fail makes with the absolute direction of the wind, provided the fail be always trimmed in the same manner with respect to the keel, and that, in the triangle CIK , the side CK and the angle CIK are constant, and the velocities of failing CI are proportional to the sine of the angle CKI , equal to the angle of incidence VCE ; it follows, that, all the other conditions being the same, the more the sine of the angle VCE is augmented, the greater will the rate of failing be; so that, if you want to carry it to the greatest rapidity, you have only to make a right angle of the angle VCE formed by the absolute or real direction of the wind with the fail; then the velocity CI will no longer be a simple chord in the circle CKI , but a diameter. This holds good for all the ships which have but one fail set; but, whenever they shall have several, the greatest velocity will be when the apparent angle of incidence of the wind upon the fail makes a right angle with the course; because then the fails will easily make, with the apparent

rent wind, an angle, of which the tangent will be double that of the angle they make with the course, without their becalming one another; while, at the same time, the ship will receive all the absolute impulse of the wind, because she does not recede from it, and it is the time when the greatest surface of sail is exposed to its impulse. The same advantage of the greatest velocity will still be had, when the apparent direction of the wind makes an angle of a hundred degrees with the course; and, in this situation, the velocity will in some degree be increased. In a word, whenever the after-sails do not becalm those forward, the ship's rapidity may always be increased, by trimming the sails as directed (n. 28): but when the sails take the wind from one another, an increase of velocity can no longer be pretended to.

We are now going to demonstrate the exactness of the rule given before. (§. 29.) When it is required to get off shore, or recede from a given right line with all possible expedition, or to keep absolutely as close to the wind as the ship will lie; CM (fig. 11, page 57) is the absolute direction of the wind; the circle $CKLI$ marks all the points at which the ship can arrive with the same sail, the same disposition, without alteration of lee-way, and at the same time; and CL is the right line from which she is to move. Knowing the angle that line makes with the absolute direction of the wind VM , it is evident that the point I of the circumference, where the course ought to end, is in the middle of the arc CLI , of which CL is the chord: and all the points from one part to the other of CI , where the ship can come to at the same time, are less distant from CL , since DI , perpendicular to CL , divides it into two equal parts, and is the longest of all the perpendiculars which can be drawn from the circumference CLI ; but the point I cannot be taken without rendering the angle LCI equal to the angle CKI , which itself is equal to the angle VCZ .

ARTICLE III.

A TABLE OF THE SITUATION OF THE SAILS TO RUN WITH
THE GREATEST VELOCITY.

M. BOUGUER.

Angles of the ap- parent direction of the wind and course.		Angles of the fails with the keel.		Angles of apparent incidence of the wind on the fails.	
D.	M.	D.	M.	D.	M.
180	00	90	00	90	00
176	15	87	30	88	45
174	37	86	25	88	12
172	30	85	00	87	30
168	44	82	30	86	14
164	58	80	00	84	58
161	10	77	30	83	40
157	22	75	00	82	20
153	33	72	30	81	03
149	41	70	00	79	41
145	48	67	30	78	18
141	53	65	00	76	53
137	55	62	30	75	25
133	54	60	00	73	54
129	50	57	30	72	20
125	42	55	00	70	42
121	31	52	30	66	01
117	14	50	00	67	14
112	53	47	30	65	23
108	26	45	00	63	26
103	53	42	30	61	23
99	13	40	00	59	13
94	25	37	30	56	55
89	28	35	00	54	28
84	23	32	30	51	53
79	06	30	00	49	06
73	39	27	30	46	09
68	00	25	00	43	00

The foregoing TABLE can be of no great service, except in the eight last circumstances under the line *a, b*; because, in all the cases mentioned above that line, the fails will cover one another too much.

When

When a fast-sailing ship (such as will, on a direct course, or right before it, take a third or a fourth part of the velocity of the wind) comes to run with the same quantity, or more sail, on a perpendicular to the apparent direction of the wind, then she acquires a greater rapidity of sailing with respect to the velocity of the wind; the angle made by the two directions, the apparent and the absolute, is at that time very considerable; it may be from 18° to $22^{\circ} 30'$; and if the ship hauls quite close by the wind, the angle will still be nearly the same; for, her velocity diminishes: but, as it is in sailing by the wind that it is most essential to know the greatness of the angle between the two directions of the wind, let the angle between the directions of the ship's head on the different tacks be observed, without paying any regard to the lee-way, but just to the exact point on which the ship stands, before and after going about, when strictly by the wind, neither too much to leeward nor to windward; and, when you have determined that angle, from two or three observations, halve it, and then you will have the angle formed by the keel and the absolute direction of the wind; by which you will know the quantity she will come to upon the different tacks, and will never be deceived with respect to the lying on after having gone about: a mistake pretty commonly made by those who pay attention only to the apparent direction of the wind, which always makes with the real one an angle more or less open in a compound ratio of the greatest velocity with the greatest obliquity of the course of the ship, with respect to the direction and the absolute velocity of the wind; things which vary in all ships, because they have not all the same advantage of sailing with the same rapidity in similar circumstances.

CHAPTER IV.

OF THE SAILS WHICH ARE BEFORE THE CENTRE OF GRAVITY OF A SHIP.

30. THE sails which are before the centre of gravity of a ship are the sprit-fail, sprit-fail top-fail, the jib, the fore-top-mast stay-fail, and the fore stay-fail.

Besides these sails there are, on the foremast, the forefail, fore-topfail, fore-topgallant-fail, and fore-topgallant-royal-fail, with their respective studding-fails. Now these four last sails may be regarded as only one large fail, wide at the foot and tapering towards the head, and which can be reduced, as occasion requires, either by taking in the royal, or by reefing the fore-topfail, or even taking it quite in, if necessary, to have the forefail only set; or by hauling the forefail up, if nothing but the topfail is wanted. It must notwithstanding be observed, that the different parts of the whole fail may, in certain cases, be worked differently the one from the other; as, for example, in reefing the top-fail, or in taking in either the one or the other. But, when you want to set them to work all together, either for making a course, or performing some evolution, they must all be braced and trimmed in the same form, and with the greatest uniformity possible. Therefore, whatever we shall say concerning one of them in any operation, is to be understood to be the same with respect to all the rest.

The main-stay-fail, the main-top-mast stay-fail, the middle-stay-fail, and the main-top-gallant stay-fail, are likewise sails of the fore-part of the ship's centre of gravity.

ARTICLE I.

OF THE EFFECT OF THE FORE-AND-AFT SAILS, WHICH ARE ON THE FORE PART OF THE CENTRE OF GRAVITY OF A SHIP.

31. The jib and stay-sails being of a triangular figure, their centre of gravity is easily found; and that point is to be considered as the part, in all these sails, on which the whole effort of the wind is united, when they are exposed to its impulse, in whatever way it strikes them.

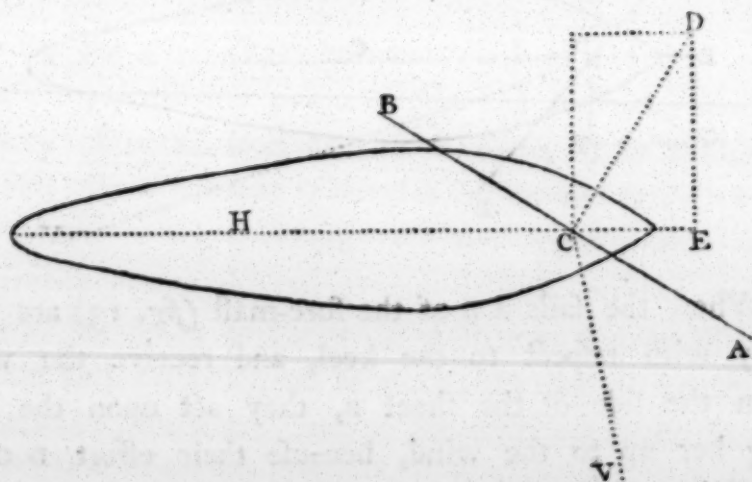
The particular effort of each fore-and-aft sail being on the fore part of the centre of gravity of the ship, it follows that the total effort of all these sails must be there too; and that, if the ship was in a perfect equilibrium with respect to the wind, before her sails were set, she will lose it immediately after (§. 11) they make the fore part of the ship obey the wind, whenever it strikes them perpendicularly or obliquely. For, it must be observed, that almost all these sails have their tacks in the middle of the ship, and their sheets lead to the sides; so that they make with the keel a very acute angle: whence it is easy to conceive, that the perpendicular which would be raised on the exterior surface of these sails, in the direction of their efforts to leeward, from their centre of gravity, would differ but very little in the lateral direction from a perpendicular to the keel. From this we may therefore conclude, that these sails would have but very little effect to accelerate the rapidity of sailing with respect to their position, if it was not demonstrated that they are very advantageous in going by the wind. They make the ship steer well, and are particularly useful when a ship grips much: and, when they do not take the wind out of any of the lower sails, they ought to be used, particularly when one is obliged to sail by the wind, or to run not very large. The jib and fore-

fore-top-mast stay-sail must be preferred, because they are at all times useful when they can receive the wind; for, by their position, they cannot take the wind out of any of the other sails, and their particular effect in veering is considerable, not only on account of their great surface, but because they act before the point on which the ship turns with a very long arm of a lever. (§. 17.) Besides, all sails, which raise a ship's head, assist her progress: for the direction of their effort ascending obliquely towards the horizon, they do not make her plunge in the water, which is an advantage peculiar to these sails. Experience has confirmed their utility on all occasions when they can be employed without taking the wind out of the other sails.

ARTICLE II.

OF THE EFFECT OF THE FORE-SAIL, FORE TOP-SAIL, FORE TOP-GALLANT-SAIL, AND SPRIT-SAIL, IN THEIR DIFFERENT SITUATIONS.

FIGURE 12.



32. When the sail AB (*fig. 12*) is trimmed close to the wind which blows from the point v, it is impelled in the direction

K 2

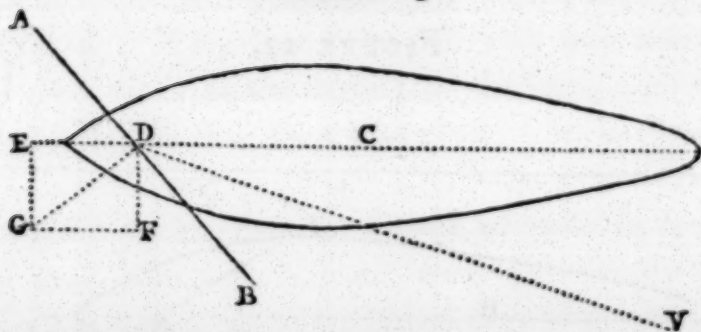
C D

CD (§. 7) with a force expressed by the square of the sine of incidence, and composed of the two effects CE and ED . (§. 19.) But, as the centre of effort of that sail AB is on the fore part of the centre of gravity of the ship H , and as its power CD is always decomposed between those two effects CE and ED , it follows, that the effect of this sail is to cause the ship to bear away; while it keeps up at the same time, and even augments, the rapidity of failing.

33. If the fore-sail AB received the impulse of the wind perpendicularly, it would still produce the effects of bearing away, and augmenting the rate of failing, for the reasons just given above, but more effectually would it do so (§. 29) on account of the increase of the impulse of the wind upon the sail.

34. It follows, from what has been said, that when the sails upon the fore-mast are full, on the same side they are tacked, being braced obliquely to the keel, there is always one part of their effort, in proportion to the obliquity, which acts to make the ship bear away; while the other part of their effort acts at the same time to accelerate or keep up the rate of her failing.

FIGURE 13.

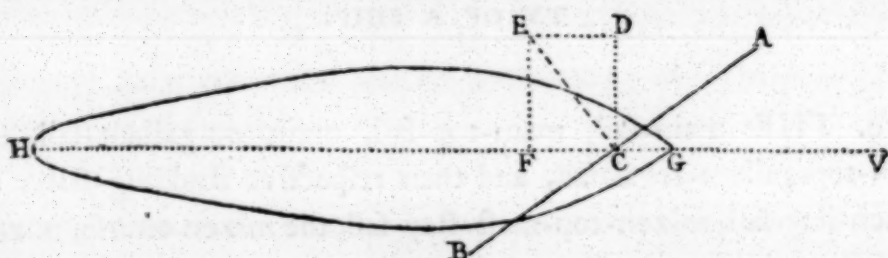


35. When the sails AB of the fore-mast (*fig. 13*) are situated obliquely with respect to the keel, and receive the wind in them, on the side of the sheet B , they act upon the ship in bringing her up to the wind, because their effort DC being decomposed, as customary, the lateral part DF carries the fore part of the ship towards the source of the wind V , in carrying her from D to F .

36. In

36. In general, when the yards are square or perpendicular to the keel, it is evident that they will act on the ship, only by impelling her right in the direction of the keel, from stern to head, or from head to stern, with more or less velocity, in proportion to the impulse of the fluid which strikes them.

FIGURE 14.



37. When the sails *A B* on the fore-mast (*fig. 14*) receive the impulse of the wind *v* on their surfaces forward, they will make the ship both go a-stern and fall off; because the direction *c e* of their effort, being turned towards the after-part, serves as a diagonal to the parallelogram *F D*; which, by discomposing it, will shew us those two effects *c F* and *c D*; the first of which takes its direction with that of the keel from forward ast, while the second takes it in a lateral direction in making the ship to turn.

38. When the wind blows between the keel and the yard, the ship comes to, until the point G (*fig. 14*) is in the direction of the wind v. But, as soon as this is done, it is evident that she falls off; for the point G recedes farther and farther from the direction of the wind. Whence we may remark, that, as soon as the weather-part of the sail catches a-back, on the tack side, the angle of incidence of the wind on it goes continually increasing, till the ship has fallen off so much, that her sail becomes perpendicular to its direction: and, if the vessel continues to fall off, then the angle of incidence diminishes more and more, till the sail is parallel to the course of the wind which comes from the tack B, or, as it is called, *shivering*.

CHAPTER V.

OF THE SAILS WHICH ARE ABAFT THE CENTRE OF GRAVITY OF A SHIP.

39. THE main-fail, main-top-fail, main-top-gallant-fail, and main-top-gallant-royal-fail, and their respective studding-fails; the mizen-stay-fail, mizen-top-mast-stay-fail, the mizen-course, mizen-top-fail, mizen-top-gallant-fail, and mizen-top-gallant-royal-fail, are all fails which are placed abaft the centre of gravity of a ship, the point round which the total effort of the fails is placed.

ARTICLE I.

OF THE EFFECT OF THE FORE-AND-AFT SAILS ABAFT THE CENTRE OF GRAVITY OF A SHIP.

40. The centre of effort of these fails being abaft the centre of gravity of the ship, it follows that they always force the after-part of the ship to leeward, and consequently contribute to bring her to the wind, as soon as they receive its impulse; for, that movement of the after-part of the ship cannot happen, without the head approaching to the direction of the wind.

The fore-and-aft sails being in general situated very obliquely, it follows, consistently with principles, that they are very advantageous for sailing by the wind. Therefore, we must not neglect augmenting them: observing, at the same time, that they do not take the wind out of one another, nor becalm the principal fails.

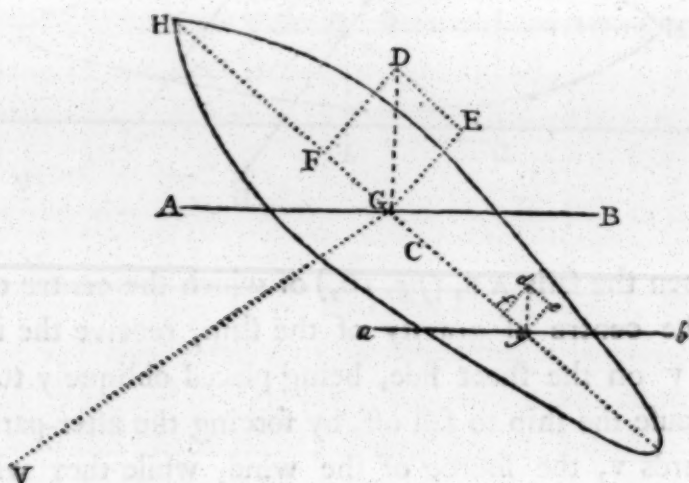
They

They are only to fill up the space between the masts fore and aft, in sailing near the wind, in order that no wind may be lost.

ARTICLE. II.

OF THE EFFECT OF THE SQUARE SAILS OF THE MAIN-
MAST, AND OF THE MIZEN-TOP-SAIL, IN THEIR DIFFER-
ENT OBLIQUITIES.

FIGURE 15.

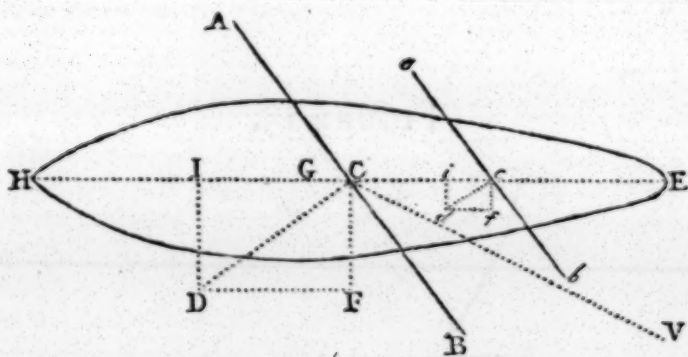


41. As we have already demonstrated (§. 19) that when the sail A B (*fig. 15*) is trimmed obliquely to the keel, it produces evidently two effects on the ship; it must therefore follow, that, in dissolving its power c D, we shall find its compound effects, the one c F, in the direction of the keel which produces the velocity, and the other c E lateral, which (in forcing the after-part of the ship to leeward, by its action on the point c abaft the centre of gravity G of the ship) occasions her to come to the wind; for that motion of the stern from c to E cannot take place, unless the fore-part H acts contrarily in coming towards the point from which the wind blows, v.

42. If

42. If the sails A B were more or less oblique to the keel, they would still have the same effects of keeping up the ship's velocity, and bringing her to the wind. And, if they receive its impulse perpendicularly, it would still be the same thing, producing those two effects, however, with greater efficacy than in any other situation with respect to the wind, because then they receive its greatest possible impulse for the time.

FIGURE 16.

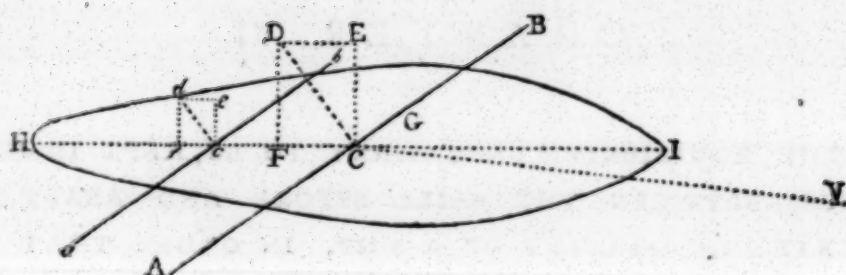


43. When the sails A B, (*fig. 16,*) of which the centre of effort c is abaft the centre of gravity of the ship, receive the impulse of the wind v on the sheet side, being placed obliquely to the keel, they will cause the ship to fall off, by forcing the after-part, from c to F, towards v, the source of the wind, while they will, at the same time, keep up the velocity c I. For, this motion of the after-part E towards v cannot be executed without the fore-part H going, as it moves off, in a contrary direction; and she will continue to fall off till the keel E H be right in the direction of the wind v c, or right aft; then the ship will come to the wind, as shewn in the two preceding articles.

It may be remarked that, in this movement of the ship, the angle of incidence goes continually increasing till the wind is perpendicular to the sails.

FIGURE

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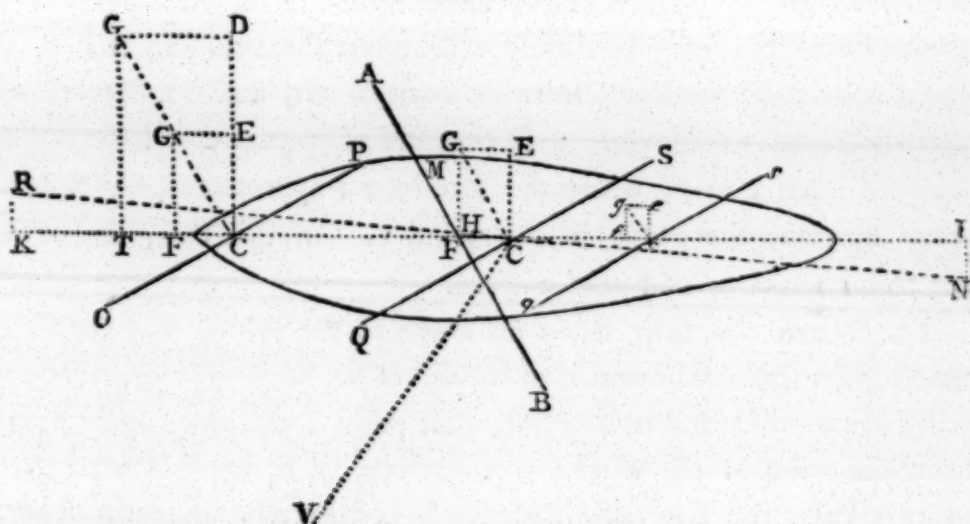
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CHAPTER VI.

OF THE EQUILIBRIUM NECESSARY TO BE KEPT IN PRACTICE, BETWEEN THE SAILS BEFORE AND ABAFT THE CENTRE OF GRAVITY OF A SHIP, IN ORDER THAT THE SAILING MAY BE THE MOST DIRECT AND THE MOST RAPID.

FIGURE 18.



46. AFTER having demonstrated the different effects of the sails both before and abaft the centre of gravity, it is clear that if either the head or after sails only were set, in sailing by the wind, the ship would not only steer badly, but consequently sail not so fast as she could under the same quantity of surface differently disposed. For, if the ship be supposed (*fig. 18*) to be under her head-sails, and one half be retrenched and set on the masts abaft, it will evidently appear that the velocity CT they produced is the same, since the direction and the velocity of the wind act always in the same manner on the same quantity of surfaces; the only difference which will be found is, that the primitive effect is

is divided, and acts now on the points c, c, E , before and abaft the centre of gravity of the ship. It is not the same with respect to the effect $c D$, which acted only on the head of the vessel in the first disposition of the sails; because, that effect being now divided on the after-masts, it is diminished one-half $c E$ forward, by reason of that force being transported aft; where, balancing the effect of falling-off produced by the head-sails, it keeps the ship to the wind; by equality in the movements (§. 34 and 42) I say that it *balances*, because, when the weather permits, we may at any time either increase or diminish the sails, so as to preserve an equilibrium between their powers, and fix the ship on her course. When this point of equilibrium is obtained, we then possess the most advantageous disposition the sails can have for the vessel to run with the greatest celerity; provided that they have been trimmed in the most favourable manner to receive (§. 28) the greatest impulse of the wind.

This equilibrium between the powers of the sails forward and aft is likewise advantageous with respect to the rudder; because, as there is less occasion to use it to regulate the movements of the ship, its surface opposes itself but little, and less often to the shock of the water, which glides along the ship's bottom. It is then of the greatest importance, in endeavouring to increase the ship's way, to combine, as much as possible, the reciprocal effect of the sails fore and aft; either in setting them to the wind, or in disposing more advantageously, forward or abaft, a greater or a less quantity of sails, according as the ship is more or less inclined to fall off or come to, in order to make as little use of the helm as possible; the whole power of which, however, at the time of performing any evolution, must be put in action, as we shall make appear hereafter.

47. When there is an equilibrium between the sails fore and aft, the resistance of the water from A to B (*fig. 18*) on the bows is equal to the power of the sails, whether it passes through the centre of gravity H of the ship, or through another point of the axis, more or less forward or aft; then a ship, thus situated, finds no more difficulty to veer than to come to the wind, with respect to the resistance of the water under her lee; since all things are

equal, viz. the resistance of the water upon the bottom to leeward, and the impulse of the wind upon the sails. But it must be considered that the power, composed of those of all the sails united, acts upon the ship according to the direction BA , perpendicular to their surfaces, the origin of which is the point H , a middle between all the effects CG of the sails fore and aft, which ought to correspond exactly with the resistance of the water from A to B : so that the ship is pushed to leeward of the course IK , which she holds into the direction BA of the effort of her sails; but the resistance which she finds from the water on the lee-side of her bottom, from A to B , sets her to rights again by its opposition, which is greater by reason of the greater facility she finds in dividing the fluid with her stem than with her side; so that she runs on the true course NR , which approaches nearer to that on which she steers than BA . Therefore the angle KHR of the lee-way is proportional to the greater or less resistance the ship finds laterally from the fluid under her lee; which resistance depends entirely on the more or less facility she finds in dividing the water with her bows; so that the lee-way can never be considerable but when close-hauled; for this reason, it is not much taken notice of when the course is less oblique than the wind on the beam. We might pursue this reasoning still farther, from an experienced fact, which will prove that the lee-way depends, not only on the form of vessels, but still more on their greater or less velocity, and seldom or never on the entire disposition of their sails more or less oblique to the keel, as some authors have advanced. For, when a fine sailing vessel is trimmed sharp, with all her sails set, in a very light breeze, with which she scarcely obeys the rudder, the lee-way is considerable, though the sea be perfectly smooth. This great lee-way is made by the ship, because the vessel being only gently impelled, and with little force, the water, not being shocked with violence, offers little resistance, and she is then carried easily by her sails in the direction of their effort BA : and, if we consider the side of the ship, in the act of sailing, as presenting a very great surface of sails above the water, it will visibly appear the lee-way will become still more perpendicular to the keel. But, let the wind begin to freshen, then the rapidity of sailing augments considerably;

rably; the ship shocks the water with a force expressed by the square of six or nine knots of velocity from B to A (*fig. 18*) in the space of an hour, while the water repels her effort in a contrary direction: the water repels then in the ratio of this square to the square of her first velocity, and now no longer yields with facility (§. 4); the lee-way is suddenly diminished, and is reduced to five or six degrees, and sometimes less, if the rapidity of sailing continues to increase; if, at the very time when the ship has acquired already a very great velocity, she be kept away 12° or 15° , or even $20^{\circ} 30'$, without altering the sails, their obliquity remaining the same, the ship should then fall off in the same proportion, according to the opinion of some who have written on the theory of the working of ships. This, notwithstanding, never happens; the velocity augments, because the sails then receive the wind with a greater sine of incidence, and thereby acquire more power, while the bows continue to be still shocked by the fluid in the same parts, and with the same sine of incidence; so that the lee-way diminishes again, because the water makes a greater resistance from the increase of velocity; and that resistance is greater on the ship's side than on her bows, which is less exposed to the shock. Whence it must be concluded that the lee-way, in the same ship, does not depend alone on the disposition of her sails, and that in different ships it is always dissimilar, from their not having the same form, or their sails not trimming equally in the same oblique courses; and because, in short, they have different velocities with the same weather and under the same sails. Which proves, in a word, that the lee-way is always in a proportion compounded of the velocity of the ship; of her form, which gives her more or less resistance on her side than on the bows; and of her sails, trimmed more or less obliquely.

To return to the consideration of the action of the water on the bottom from A to B, (*fig. 18,*) it must be remarked, that it acts forward, and that it must consequently contribute very much to the tendency which almost all ships have to come to the wind, whenever the after-sails are in the smallest degree more powerful than those forward: for, the shock of the water is then a power which is to be added to that of the impulse of the after-sails, since
this

this action of the fluid is so much the stronger as it acts before the centre of gravity of the ship at the point M, (*fig. 18,*) in impelling the fore-part towards the wind, which always makes ships difficult to ware, because all the effort AB of the water's resistance upon the bows is opposed to this movement, in forcing this part to windward with a very great effort. It is not therefore to be wondered at when ships veer with difficulty or slowly, especially such as have a large cut-water; because there are two forces acting one against the other, and the force which comes from the sail must surmount (§. 18) that which comes from the water; which will always easily happen, whenever, in suppressing some of the after-sails, those forwards shall be disposed favourably enough to produce that effect; and when the rudder is used at the same time; the power of which is considerable, whether the ship goes a-head or a-stern rapidly. But if the ship, being abandoned to her own proper movements in an oblique course, had on a sudden all her sails suppressed, the vessel would come to the wind, should even the rudder never be used; because the water, acting on the fore-part of her bottom more on one side than the other, impels the head to windward against the smaller resistance, until its power is entirely destroyed by the total cessation of the ship's velocity.

When the ship runs so large that the after-sails becalm part of those forward, this is again another reason for the ship having an inclination to come to the wind; for, the sails forward receive a much less impulse from the wind than in a course more oblique; because the sails abaft, by increasing in their power, prevent those forward from having as much wind as their surfaces would take, since all the lee-parts of these sails become useless for the moment, being becalmed by the weather-part of those on the main mast; so that the power of the sails forward diminishes, while that of the after-sails increases; for the sine of incidence is greater. The ship ought then, for these reasons, to have more inclination to come to the wind; but, regard must be paid to the direction of the power of the sails in general, which now approaches nearer the direction of the keel: so that the greatest part of their effort is in that direction, while their force in the lateral one diminishes.

It should be farther observed, that when the ship has as much sail as the weather will permit her to carry, that is the moment of the greatest velocity of sailing, provided that (the sails having at the same time received the most favourable disposition) an exact equilibrium has also been placed between those afore and those aft, so that there should be little occasion for the use of the rudder.

APPLICATION.

48. One may readily discover, from what precedes, how to distinguish the degree of quickness with which different operations ought to be performed. For example, being obliged to run for a roadstead, the wind being large, and to let go an anchor as soon as come to it, it is evident this ought to be executed but under little sail, which should be all on the part before the centre of gravity; because, in the first place, a ship has always velocity enough when she sails large; secondly, because she is to overcome the effort *AB* (*fig. 18*) of the water which opposes her movement. If, on the contrary, being obliged to come to the wind in anchoring, as many sails as can conveniently be managed at that moment may be set, because that movement of the ship is always very quick, and as soon as the sails are taken a-back, the rapidity of the ship's way diminishes, and in a few moments entirely ceases, whereas it always augments when the ship falls off.

ARTICLE I.

REMARKS ON THE EFFECT OF THE MAIN-SAIL.

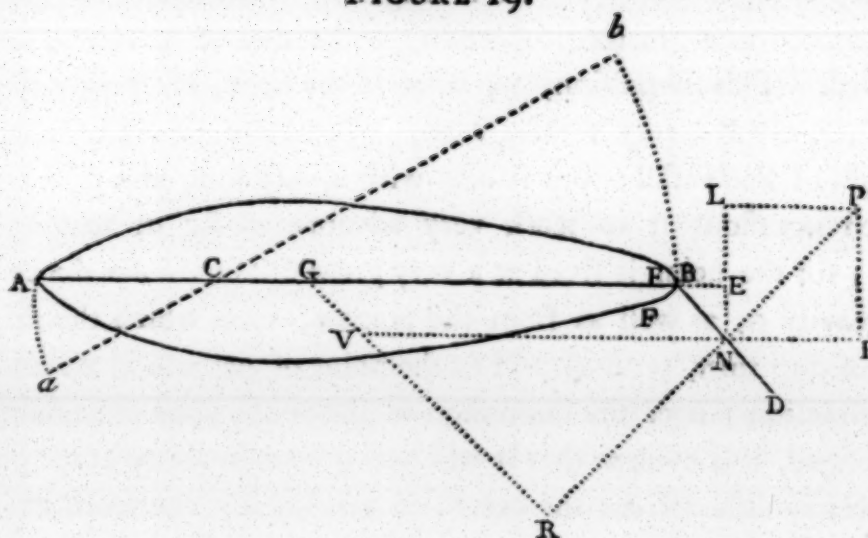
49. In the use of the sails, attention should be paid to the effect of the main-sail, which perhaps may not be that of bringing the ship to the wind; for, if the ship be too much loaded a-stern, the
centre

centre of gravity H (*fig. 18*) of the ship might be abaft the main-mast, and then the direction of the effort of that sail, quitting the point c before the centre of gravity, ought to make the ship fall off in lieu of keeping her up to the wind. But, for this to happen, the ship must be either very ill constructed or very badly loaded; or, in short, there must be great error in the position of her masts. Notwithstanding the main-sail may always be made to assist the ship in veering, though the centre of gravity H be (as it is almost always) before the effort c of the main-sail; yet, to do it, the effect of that sail need only be changed, by making it to pass before the centre of gravity of the ship: which will suddenly happen, if, when close-hauled, the main sheet be let go a-main, because the weather-part of the sail being fixed forward by the tack, its effect is likewise before the centre of gravity of the ship, though it has lost in that part much of its power, in becoming less exposed to the impulse of the wind; while the lee-part, bellying out more, can receive a great impulsion of the wind, which will strike it more and more perpendicularly as the ship falls off with more and more rapidity. In this case, it may happen, that if the direction of the effort cG of the main-sail do not pass before the centre of gravity H of the ship, it comes so near that point, that it may be said to have no longer the effect of an after-sail.

ARTICLE II.

OF THE RUDDER.

FIGURE 19.



50. The rudder is a machine known to all the marine world; it is supported by the stern-post, to which it is affixed by braces and pintles, which operate as hinges. It acts by means of a lever, called a tiller, which enters nearly horizontally into the ship, passing under the upper or middle deck transom; so that if, instead of leaving the rudder exactly in a right line with the keel, and as it were a prolongation of it, it be turned to one side or the other, as BD , (*fig. 19*,) it receives an immediate shock from the water which glides along the ship's bottom, in running aft from A to B ; and this fluid impels it towards the opposite side, while it continues in that situation, so that the stern, to which the rudder is confined, receives the same movement; and, the ship receiving an impulse sideways, her stern turns accordingly from B to b , on any point whatever c , (§. 18,) while her head passes from A to a . It must be observed, that the water strikes the rudder obliquely, and only with that part of its motion which acts according to the sine

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of

of incidence, in impelling it in the direction NP with a force which depends not only on the rapidity of sailing, but also on the greatness of the sine of incidence: a force which is consequently in the compound ratio of the square of the greater or less velocity of the ship's motion, and of the square of the larger or smaller sine of incidence, which depends upon various circumstances. So that, if the vessel runs three or four times more swiftly, the absolute shock of the water upon the rudder will be nine or sixteen times stronger under the same angle of incidence, and will be augmented in a greater proportion, if the sine of incidence be increased. This impulsion, or, what is the same, the power of the helm, is always very feeble, when it is compared with the whole weight of the vessel; but it acts with a very long arm of a lever, which occasions it to work very advantageously in turning the ship; for the helm is fixed at a very great distance from the centre of gravity G , as well as from the point c , upon which the ship is supposed to turn, with respect to the point of percussion B : and, if the direction PN of the impression of the water upon the rudder be prolonged, it is evident that it will pass perpendicularly at the point R , widely distant from the centre of gravity G ; therefore the absolute effort of the water is very powerful. It is not therefore surprising, that this machine impresses the ship with a considerable circular movement, by forcing the stern from B to b , and the head from A to a , and even much farther, when the velocity of the ship is preserved; because the effect of the helm always keeps pace with the rapidity of the ship's way.

51. Amongst all the obliquities which may be given to the rudder, there is one situation which is more favourable than any of the others, to make it produce with more rapidity the effect of turning the ship, in order to change her course. To be convinced of this, we have only to consider that, if the obtuse angle ABD (*fig. 19*) were to be lessened, the impulse of the water on the rudder would augment, at the same time that it would more oppose the sailing of the ship, since the angle of incidence would be more open, and would present a greater surface (§. 7) to the shock of the water, by opposing its passage more perpendicularly: but then the direction NP of the effort of the helm upon the ship would pass

at

at a smaller distance from the centre of gravity G towards R , and would less approach the perpendicular NL , according to which, it is absolutely necessary that the power should act with greater effect to turn the ship. Therefore, it is evident that, if the obtuse angle ABD were too much lessened, the greater shock of the water could not counterbalance the loss occasioned by the distance between the direction NP and NL , or by the great obliquity which would be given to the same direction NP of the absolute effort of the helm with the keel AB . If, on the other hand, the angle ABD were made more obtuse, the direction NP of the effort of the rudder would become more advantageous to turn the ship, since it would approach more the perpendicular NL , and since the prolongation of NP would augment GR , by passing at a greater distance from the centre of gravity G . But the rudder would then be struck too obliquely; for the angle of incidence would be more acute; so that it would only present a small part of its breadth to the shock of the water, and would of course receive but a faint impulsion. All this proves that the greatest distance GR from the centre of gravity G will not counterbalance the too great obliquity of the shock of the water. Whence it must be concluded, that when the water strikes the rudder too obliquely or too perpendicularly, a great deal of the impulsion, or of the effect it should produce, is lost. Therefore, between these two extremes, there is a middle position, which must be the most favourable.

52. The diagonal NP of the rectangle IL (*fig. 19*) represents the absolute direction of the effort of the water upon the rudder: NI expresses the portion of this effort which opposes the ship's head-way, or which forces her a-stern in the direction of the keel. It is easy to perceive that this portion NI of the whole power of the helm contributes little to turn the vessel; for, if IN were prolonged, it would be seen that its direction passes at a very small distance Gv from the centre of gravity G , and that the arm of the lever $BN = Gv$, to which the force is as it were affixed, is at most equal only to one-half of the breadth of the rudder. But, it is not so with respect to the relative force NL , which acts perpendicularly to the keel. If the first force NI is almost useless, and even hurtful, by retarding the velocity, the second NL is capable

of a very great effect, since it is applied at a great distance from the centre of gravity G of the ship, and acts on the arm of a lever GE , which is very long. Thus, it appears, that, between the two effects NL and NI , which result from the absolute effort NP , there is one which is always opposing the ship's head-way, contributing but little therefore to the motion of her turning; whilst the other alone produces that movement of evolution without retarding her velocity.

53. Geometricians have determined the most advantageous angle made by the helm with a line prolonged from the keel, and fixed it at $54^{\circ} 44'$, on a presumption that the ship is not wider at her floating-line than at her keel. But, as that supposition is absolutely false, since all vessels augment their breadth from the keel upwards to the extreme breadth where the floating-line, or highest water-line, is terminated; it follows, that this angle is too large by a certain number of degrees. For the rudder is shocked by the water, at the height of the floating-line, more perpendicularly than at the keel, since the fluid exactly follows the outlines of the bottom: so that one could almost say, that a particular position of the helm might be required for each different sine of incidence upwards from the keel. But, as a middle position may be taken between all those points, we need only consider the angle formed by the sides of the ship and her axis at the highest water-line, in order to determine afterwards the middle point and the middle angle of incidence. It appears, from Mr. Bouguer's *Traité de la Manœuvre*, Sect. L. Liv. II. that, in most ships, the angle of the rudder with the prolonged line of the keel should be made to be $46^{\circ} 40'$. Without following the calculations of that able geometrician, we shall perhaps be able to explain what he has discussed in a more abstruse manner.

54. When it is required to turn the ship by means of the rudder, and, at the same time, keeping the head-way as much as possible, it is evident that the angle $54^{\circ} 44'$, which some have determined to be the most favourable with the line of the keel prolonged, is in that case too open; because the water strikes the rudder with too great a sine of incidence, and which is equal to that of the angle which it makes with the line prolonged from the keel below.

Above,

Above, the shock of the water is almost perpendicular to the rudder, on account of the width of the ship's sides, as has been shewn before. But, if the rudder opposes the fluid by making only with the line prolonged from the keel an angle of $45^{\circ} 1'$, the impulse, by becoming weaker, will be less opposed to the ship's head-way; and the direction NP (*fig. 19*) of the absolute effort of the water on the rudder, approaching nearer to the lateral perpendicular NL , will be more advantageously placed; since the prolongation of the absolute effort passes at a greater distance GR from the centre of gravity G . On the other hand, experience every day shews us that ships steer well, when they do not even make the angle DBE more than 35° . If this angle be made 45° , as we require it, and then we should discompose the absolute effort NP , we have the side NI equal to the other side NL of the same square; so that the part of the total power which opposes the head-way is only equal, in this case, to that which produces the movement of rotation: instead of which, if DBE were $54^{\circ} 44'$, NI would become much greater than NL , in proportion to the sines of the angles which are opposed to them in the triangles PIN or PLN , and the ship would consequently lose much more of her velocity than in the first situation of the rudder, to which we shall confine ourselves, as being that which is best adapted to the generality of vessels, but which nevertheless must be occasionally altered, according as they shall make an angle more or less open with their sides a-stern.*

The angle of the rudder with the keel may always be determined with sufficient precision, by observing the rule we have prescribed (§. 28) for the determination of the angle of the sails.

55. As the water often strikes the rudder with a very great force, the tiller has a certain length, in order to lessen the labour of the helmsman.

But, to lighten his labour still more, there is in most ships, on the quarter-deck, directly over the extremity of the tiller, a vertical wheel (*fig. 19*) which has the effect of a capstern, and which

* It may be taken as a general position that the most advantageous angle will always be formed between 35° and 45° .

is connected with the tiller by means of ropes and blocks. So that, if the wheel be turned either one way or the other, the extremity of the tiller approaches towards one of the sides of the ship, and exposes the rudder to the shock of the fluid.

56. The longer a lever is, the more effect it has when it acts with the same power: therefore, the longer the spokes of the wheel are, in proportion to the radius of the cylinder round which the tiller-rope is wound, the more advantage the helmsman will have; for, if the spokes of the wheel be three or four times longer than the radius of the cylinder, the helmsman will act with three or four times more force, since he works on a lever which is three or four times longer than the radius of the cylinder, the extremity of which is supposed to be the fulcrum of the lever on which he works. So that, if he employs a force of 30 pounds weight, he will produce an effect of 90 or 120 pounds, by the disposition of the wheel alone. On the other hand, the impulse of the water is collected in the middle of the rudder's breadth, which is very narrow, compared with the length of the tiller; therefore, the effort of the water is very little distant from the point of support B upon which it turns: whereas the tiller forms the arm of a lever 10 or 15 times longer, which still increases the power of the helmsman in a similar proportion to that which exists between the length of the tiller and that of the lever on which the impulse of the water acts. This force is therefore 10 or 15 times stronger; and the effort of 30 pounds, which before gave the helmsman a power of 90 or 120 pounds, will become one of 900 or 1800 pounds on the rudder. This advantage proceeds from the water's acting on a very short arm of a lever, while the helmsman works on one very powerful, in comparison; and because this lever is moved by a wheel which multiplies its force. This demonstration ought to remove all surprise at the prodigious effect of the ruder, when its mechanism is not attended to; for we have only to consider the pressure of the water, which acts at a very great distance from the centre of gravity G of the ship, as well as from the point c upon which she is supposed to turn, (§. 15,) and there will easily be perceived the difference which exists between the effort

of the water against the helmsman and the effect of that same impulsion against the ship. With respect to the helmsman, the water acts with the arm of a lever NB very short, of which B is the fulcrum: on the contrary, with respect to the ship, the impulse of the water is exerted in a direction NP , which passes perpendicularly at a very great distance from the centre of gravity G , in acting on a very long lever EG , which renders the action of the rudder very powerful in turning the ship: so that, if in a large ship, the rudder receives an impulse from the water 2700 or 2800 pounds, (as very often happens, provided that the ship sail at the rate of 9 or 12 knots, and that this power, applied at E , be 100 or 110 feet from the centre of gravity G ,) it will act upon the vessel, to turn her, with a power equal to 270,000 or 308,000 pounds, while the helmsman need not act with a greater power than 30 pounds on the spokes of the wheel.

57. It is proper to remark, that the great length which is given to the tiller, in order to facilitate the work of the helmsman, is an obstacle to the play of the rudder; since that length hinders its presenting itself sufficiently to the shock of the water to produce all the effect which might attend it. For, this inconvenience does not, in most ships, allow the angle DBE (*fig. 19*) to be more open than 30° ; whereas it should be 45° , as we have before shewn. But, as this most favourable determination has not yet come into use, and the coarse dimensions commonly given the tiller have always been followed, we shall endeavour to propose something better for practice.

It must be considered, that, if the tiller were shorter, the rudder would have more play, because its extremity, in describing the arc of a smaller circle, would occasion the rudder to make an angle more open, with the keel prolonged: and this new augmentation would be so much the more advantageous, as it would approach nearer to the angle of 45° . And as, in all ships, the length of the tiller might certainly be cut a fifth shorter, or perhaps more, it is evident that, thereby, the angle of the rudder and the keel prolonged might be rendered very near 45° , which would increase its force in a proportion of nearly 3 to 5, since the square of the sine of incidence of 45° is to the square of the sine of incidence

of $30^\circ :: 5 : 3$, or thereabouts. This augmentation of the impulse is often of the greatest importance, especially when ships are of a large size, as their motions are but slow on account of their length.

If the tiller be shortened, the helmsman will be obliged to employ more force in proportion to the length taken from the lever on which he works: but this loss may be repaired by the facility with which the helm will be handled, if the diameter of the cylinder of the wheel be considerably lessened, augmenting at the same time the length of its axis, without diminishing that of its spokes, which ought on the contrary to be lengthened as much as possible, and two more turns of the tiller-rope should be wound round the barrel.

These forces would be still multiplied, if two sheaves were fixed in the end of the tiller, in two mortises which might be made for that purpose, and which might work on an iron pin passing through their centres, taking care to have the end of the tiller stoutly hooped with iron, in order to strengthen it; then the tiller-rope might be reeved through the blocks which are for that purpose on each side the ship, thence through the two sheaves at the end of the tiller, and the standing-part to be affixed close to the blocks on each side. By these means nothing would be lost with respect to the force; because, if the lever be shorter, the forces which cause its action are likewise multiplied in proportion.

58. After what has been said respecting the helm, it is easy to conceive, that the greater the ship's velocity is, the more powerful is the action of the rudder, since it acts against the water with a force which increases as the square of the velocity of the fluid, (§. 3,) whether the ship has head-way or stern-way; observing always, that in these two circumstances the effects are contrary; for, if the ship goes a-stern, the rudder will be struck from I to N; (*fig. 19*;) and, instead of being pushed from N to P, it will be so from N to R; so that, the stern being moved in the same direction, the head will take a contrary one, and move towards the same side as the tiller B F.

59. It should be observed, in the use of the rudder, that there is one part of its effort which impedes the ship's sailing when it is struck

struck by the water which runs rapidly along the ship's bottom. If it makes an angle of 45° with the keel prolonged, it receives only half the impulsion it would if acted upon perpendicularly; because the absolute impulse diminishes from two causes: (§. 7.) The surface which opposes the shock of the water is reduced to a less extent than it was at first, and the angle of incidence diminishes likewise: so that, by this, the impulse has diminished one half. Considering next the impulsion NP , which remains, (*fig. 19,*) it will appear that there is only one part NI which is opposed to the sailing, (§. 54,) and which is less than NP , in the proportion as the sine total is to the sine of 45° , the measure of the angle of incidence VNB equal to NP ; for the angle VNL is right, as well as the angle PNB ; so that, if you take away the common angle PNB , two angles PNL and VNB will remain equal between themselves; but, as the angle IPN is equal to its alternate angle PNL , it follows that IPN is always equal to VNB , whether the angle made by the rudder be more or less open with the keel prolonged. So that, if the surface of the rudder which receives the shock be 80 feet square superficies, it will first be reduced, by its being exposed to the course of the fluid, to an effort of 40 feet surface, then to 28 or 29, because, in the first place, there is only one part of the velocity of the water which contributes to the shock, and that is proportional to the relation of the square of the sine total to that of the sine of incidence; and, secondly, because out of the absolute impulse NP , which results from this last oblique shock, there is only a part NI which opposes the velocity of the ship proportional to the absolute NP , in the same relation as there is between the sine total and the sine of incidence; that is to say, that, when the rudder makes, in the largest ships, an angle of 45° , it impedes the ship's rapidity of sailing, in the direction of the keel, with an effort NI equivalent to the impulsion which a surface of 28 or 29 feet square might receive if it were exposed perpendicularly to the shock of the water. So that, if the ship sails 12 knots an hour, or 19 feet a second, the effort of the rudder NI , which opposes the ship's way, will be 12,499 or 12,945 pounds; salt water weighing $\frac{1}{35}$ th more than fresh.

60. It follows, from all that has been said of the rudder, that it ought to be employed as little as possible; that is to say, the ship and her sails ought to be so disposed, that the smallest motion of this machine may bring her to her course, if she deviates from it, or make her perform any evolution which may be thought proper.

A R T I C L E I I I .

THE TIME EMPLOYED BY DIFFERENT VESSELS TO PERFORM THE SAME EVOLUTION IS PROPORTIONED TO THEIR LENGTHS.

61. All that serves to produce motion in ships has more force in larger than in small ones; but the difficulty which large ships have to receive the motion is greater, in a greater proportion, than that which opposes the motion of small ships. For, if the dimensions and machines which compose a large vessel are twice as large as those which constitute a small one, (solidities being in ratio of their cubes,) the first will be eight times as great. Yet the obstacle which the large will oppose to its being put in motion will be two-and-thirty times as great as that of the small one. For, if both ships were considered as divided into an equal number of vertical sections, those of the large would appear to have four times as much surface as those of the small, besides that they would be twice as thick, since the dimensions are in general twice as large; consequently they will have eight times the solidity; which answers already to the relative effort of the rudder and sails.

Farther, the parts of the large ship are twice as distant from the centre of gravity as those of the small one, since those distances are proportional to the other simple dimensions of the two ships. So that if the evolution be supposed of the same number of degrees,

grees, the stern and head of the large ship will have to describe arcs twice as large as the small one; and this greater velocity being multiplied by the solidity of the parts of the large ship, which is eight times as great as that of the small one, the product will give 16 times more motion; the resistance will act consequently 16 times as much on the large as on the small; and as that resistance operates on the arm of a lever twice as long, the total resistance of the large ship will be 32 times as great. Thence it follows, that if the forces which act on the large ship be augmented only in proportion to her solidity, she will have still four times more difficulty than the small one to get into motion: and therefore the large ship, instead of making in the same time an angle of rotation as great as the small one, will only make an angle of one-fourth, or three times less. Now, that the great ship should describe an angle of rotation equal to the other vessel, it will require only thrice as much time: but that angle, or the velocity with which the ship obeys the impulse of her rudder and sails, will follow the laws of acceleration, since the velocity acquired in the first instance is continually augmenting in arithmetical progression; so that the time which similar vessels of different sizes take in performing the same evolution will be in proportion to their lengths. But the heavier body parts with its velocity not so readily as the lighter body, because the resistance of the mass is greater, being three times heavier than that of the small ship; which, being moved with thrice the facility, is also brought to rest with the same degree of ease. So that, if a vessel 100 feet long takes four minutes to perform an evolution, a similar vessel of 150 will take six minutes or thereabouts to perform the same circular movement. For as 100 : 150 :: 4 : 6.

CHAPTER VII.

OF THE HEIGHT OF MASTS.

THE correct height of the masts of ships is still a problem which remains to be solved for the builders. The most skilful of them have not paid attention enough to the solutions and determinations which are contained in the works of the late Mr. BOUGUER on that subject. It seems, on the contrary, as if they had endeavoured to deviate as much as possible from the true principles in that respect, by raising the masts a great deal more than they were formerly, although they were already much too high, as the learned author I have just mentioned has asserted. An experience, confirmed by repeated observations, has convinced me of this truth; viz. that "as soon as a ship inclines, her velocity" diminishes in proportion as her inclination increases." This principle has been verified on different vessels and at different times by several officers, and in various oblique courses. I had no share in those various experiments, and therefore cannot be suspected of partiality: but, as they have always proved, to those who have made them, that the present mode of masting is generally too high, I will not hesitate a moment longer to deliver here an epitome of my own experiments on that subject.*

Having all the sails out, and being hurried on by a strong gale, I have ordered all the top-gallant-sails, the studding and stay sails, to be taken in, without the ship losing the least perceptible degree of her velocity; nay, I have seen it sometimes to increase by a twentieth, and that at a time when the ship ran already at the rate of nine or twelve knots an hour.

* We have thought it proper to give the reasoning of M. Bourd  upon this subject, although the practice of high-masting prevails in the British navy. It has been very justly remarked, that high masts have the advantage of giving an option; because they enable a ship, without obliging her, to carry a greater quantity of sail than ships with shorter masts.

These trials, which I have made with care, and which were performed so quickly, that the wind should not have time to increase or diminish in strength, are sufficient to prove the necessity of lowering the centre of effort of the sails in general, and consequently all the masts. These experiments have been repeated by augmenting the number of sails, sometimes at the risk of fatiguing the masts; and it has always been found that the velocity did not increase, when the ship was more inclined; but that she laboured more and more in all her parts, as her movements became stronger and the concussions of her pitching rougher, although the sea was not more swelled. At other times, when the ship inclined pretty much, though the wind was not quite strong enough to hurt the masts, I have lessened the number of sails; and it happened that the ship, after that suppression of the top-sails, was easier in her movements, steering better, and was, in short, more quiet, though the swells of the sea were still the same; an attention which must not be neglected in these kinds of observations, which should be often repeated before a positive decision. However, we do not recommend any diminution in the surface of the sails, in lessening their height: but, it will often happen that we shall rather recommend to increase it upon the whole. For that which is lost in height may be regained by the width. There will even result, from that operation, another advantage: the top-sails, by this reform, being shorter, and, thereby, proportionally wider, than the lower sails, will be more easily cut to their shape; and, their sides being formed with lines exactly strait, the sail will be the more tight, by which a much greater effect on the ship will be produced. The mast being shorter and the sails wider, with less fall, the surface will be the same: but the effort of that surface will, with the same wind, act on shorter levers, the fulcrum of which will not be altered; therefore, it will operate at a shorter distance from that fulcrum; and therefore much less will be the power which makes the ship incline: and the ship, being more upright, will sail with more velocity, because her water-lines will be then more advantageous than when she heels. On the other hand, the sails being less inclined, they present a wider surface to, and receive a stronger impulsion from, the wind; an advantage which must
always

always produce an increase of swiftness and a decrease of drift. Add to this the real advantages of trimming the sails better, of working them with more ease, of rendering the masting in general more solid, and more capable of resistance in bad weather as well as in battle.

But how must we determine the height for the masts? or, in other words, how much they are to be shortened? The *Treatises on the perfect masting and working of ships*, by Mr. BOUGUER, teach us that method. It is from those Treatises I have imbibed the notions of my principles on that subject. But, in order to give a previous idea of that inquiry, and to engage the builders and seamen to bring to perfection this part both of the building and working of ships, upon which, almost as much as from their bottom, their steerage undoubtedly depends, I will subjoin here what M. BRUE, a learned and studious officer, made me conceive on that subject.

“That masting,” said he, “is absolutely perfect, when the centre of effort of the sails is precisely opposite to, or at the same height as, or parallel with, the *point velique*. What is the *point velique*? It is that point in a perpendicular, (raised from the centre of gravity of the horizontal surface of the ship at the floating-line,) which is intersected by the direction of the absolute impulse of the sea on the head of the vessel. This is the *point velique* in direct courses.”

It is clear. No great effort of imagination is necessary to conceive this principle, which appears so evident, that it may be surprising why it has not yet been made use of. For, this *point* once known, the centre of effort of the sails will be so too; and their right height, as well as that of the masts, will be determined. A little more calculation, and an attention to the plan of the ship, will be necessary, in order to find out that absolute direction of the effort of the impulsion of the water on the bows. But that should not prevent the inquiry. On the contrary, it should be an additional inducement to those, who, building such good vessels as we are now possessed of, and which might still be of a more advantageous form, will be desirous to make them more perfect, by masting them more advantageously. This would undoubtedly be the case;

case; for, several vessels have had their masts cut shorter, and the practice has been attended with decided success. These facts, which could be attested by many able seamen, will always speak highly in favour of this principle; although, when that shortening was made, the sails were not widened in proportion.

"But," continues M. BRUE, "in carrying this inquiry farther than it ever was, the intersection of the two above-mentioned lines (viz. that of the absolute impulse of the water on the bows, and that of the perpendicular of the centre of gravity of the surface of the floating-line of the ship) cannot take place unless in a direct course; and, as soon as the course becomes oblique, they no longer meet. The centre of gravity of a floating-line's surface of the ship passes to the leeward of the axis, on account of the inclination which always occurs in that sort of course: and the direction of the shock of the fluid, which then takes its origin a little to leeward also of the bow, passes, in its prolongation, to windward, without meeting the perpendicular at the centre of gravity of the floating-line's surface;" (which is easily conceived, if we represent to our imagination the horizontal edge of that floating-line's surface but ever so little inclined;) "whence it results, that no *point velique* will be found in any course but a direct one. Which is true, unless we could fancy such a ship as would neither drive nor incline in an oblique course. But that is not possible; and hence no perfect mode of masting could be discovered in the last case of the oblique course."

This is true, strictly speaking; for, in each instant of a course, a different point of the bow is struck by the water; which is owing to the pitching of the ship, the continual variations in the strength of the wind, and the greater or smaller inclination produced by the rolling motion of the ship.

"But," says again M. BRUE, "the *point velique*, relative to these various circumstances, varies therefore in the proportion of the almost infinite variety of those circumstances, which accompany the course of a ship; that is to say, according to all the degrees of drift, all the degrees of inclination on either board, forward and abaft; as many times, in short, as there are

" new

“ new points of the bow either struck or no longer struck, the
 “ *point velique* ascends or descends.

“ I pass over the minute examination I could make of each particular cause which contributes to lower that *point* from its utmost height, which is in the direct course, to its lowest, which takes place in the most oblique course, accompanied with the greatest lateral inclination of the ship. And there is no method to get out of that common road which is pursued in determining the dimensions of the masts, but that of attending to the following considerations; viz. Such a ship, being intended for such a latitude, the wind she is most commonly to expect there will be nearly of such a strength, and generally oblique to her course by so many degrees; so that her most common drift will be nearly so many degrees, and her lateral inclination so many, &c. To give her, therefore, the most suitable masting, making her relatively perfect, we must seek for her *point velique* in what situation we shall think most convenient, and there place the centre of effort of her sails.”

All this reasoning tends evidently to the shortening of all the masts, and proves the necessity of doing it, at the same time as it determines their height. The most difficult point in that operation is to find out the direction of the absolute impulsion of the water on the bows, when the ship steers a course close-hauled and one with the wind on the beam, with such an inclination as the ship could be supposed to have in either of these two courses; when the wind would allow to have four square-sails set, together with the mizen top-sail. Considering these two suppositions of the wind on the beam, and close-hauled, it will be easy to determine the height of the masts proper for that double situation; because, if the gale blows harder, one may lessen the number of sails; if weaker, one may increase it by adding stay-sails, top-gallant sails, jib, &c. If the wind gets more aft, then the surface of the sails may be increased again by adding the studding and top-gallant-royal sails: finally, it is very clear that top-gallant and top-gallant-royal sails will always be of service when the centre of effort of the sails should ascend.

CHAPTER VIII.

OBSERVATIONS ON THE DIFFERENT INCLINATIONS GIVEN
TO THE MASTING OF SHIPS, WITH RESPECT TO THE
WATER-LINE.

THE masts are hardly ever stepped in the same manner in all ships. This too is one of those things which are rather regulated by custom than reason. Some will have them perpendicular, while others choose to have them rake forward and others aft. Each party brings, to support their opinion, reasons drawn from some experiments which chance has sometimes rendered specious.

In this respect, we should rely on the judgement of the builder, who ought to know the qualities of his ship, even before he puts her on the stocks. If one has not an opportunity of taking directly from him the necessary instructions, it is proper to observe, that, if the masts are made to rake forward, the direction of effort of the sails will be inclined towards the bottom, obliquely with the horizon; which will consequently make the head of the ship plunge whenever they receive a strong impulse from the wind: and this may diminish the head-way of the ship, while it increases the celerity of the pitching; the sails also will be with more difficulty trimmed, especially when close-hauled, since the bracing of the yards will be more confined. Therefore, the only advantage, which can be drawn from this oblique masting of ships, is only to render the ships more ready to fall off.

If the masts are perpendicular the direction of effort of the sails will be horizontal, always supposing the ship to be in an upright position. Therefore, this effort, not being discomposed, it will preserve a much greater action, and the ship will sail with the greatest velocity she is capable of.

If the masts rake aft, the ship will be more ready to come to the wind, because the sails will be a little more aft; these will also be more easy to trim sharp, because the braces will not be so much confined. As this position of the sails will raise obliquely above the horizon the direction of the effort on the ship, it follows, that, by their power, the ship will be eased away from the water; for, it is certain that she will not prolong her course, unless she heels too much; therefore, she will rise more lightly over the waves, pitch less, keep better the wind, and tack quicker. This is nearly all that can be said in respect to practice.

CHAPTER IX.

OF THE TENSION OF SAILS, AND THEIR TENDENCY TO FIX THEMSELVES PERPENDICULARLY TO THE DIRECTION OF THE WIND.

I. IT is clear that sails are never perfectly flat. But every one is not persuaded that the more extended is the sail, the greater impulsion it receives from the wind which strikes it perpendicularly, and the more effectually, of course, the sail acts on the vessel. It is astonishing that any seamen should be of opinion that a bag must be left at the foot of the sail to lodge the wind in. A hauled-down top-sail has as much cloth displayed in it as when hoisted up and well extended. It forms, then, by its convexity, a considerable kind of bag, in which the wind may play at ease; and it is observed, that the rapidity of the sailing decreases very much; whence we must necessarily conclude, that the impulse of the wind must have greatly diminished, since the sail produces no longer the same effect upon the vessel. To know demonstratively the cause of that diminution in the impulse of the wind, we have only to pay

pay attention to the air which acts against the foot and the head of the sail; for, that part of the wind which strikes at the head makes an effort to re-act towards the foot against that which, having struck at the same instant at the foot, endeavours to re-act towards the head. From this shock results (though the air escapes at each side) a compression in the sail. But, after having acted inwardly, in the same manner as if it were shut up, it finds itself more and more compressed by that which succeeds to the first; and, though it escapes by the sides, it is evident that it tries to extend, and that it impels, consequently, with an equal power, all the parts of the sail perpendicularly; and this is the cause of the sail taking the form of a circle's arc. Therefore the sail will produce no greater effect than if it had no greater height than the space contained between the two yards; it may not even, strictly speaking, have that whole effect; for, that sort of whirlwind, which is made in the centre, by the re-action of the wind which strikes the upper and lower parts, cannot fail to diminish the shock of those particles, which, succeeding the former, would have struck the sail with all their primitive power; instead of which, this power is now almost entirely destroyed by this barrier which opposes for a while their passage. To which may be added, that the sail, having the form of the arc of a circle, very little wind can strike it perpendicularly; and that it must, of course, have much less effect than another sail, of the same height and width, which should be very exactly stretched out.

The sails of a ship should be cut in such a form as to present as flat a surface as possible.

II. The centre of effort of the impulse of the wind upon the sails, exposed perpendicularly to the course of the wind, answers exactly to the centre of gravity of the surface, struck in that direct situation. But, as soon as it is presented obliquely to the course of the fluid, and kept so, the centre of effort of the total impulse will pass on the weather-side of its centre of gravity; because the particles of air, which at first met the surface, have been re-acted, and, by that re-action, they stop part of the passage to the succeeding ones, which diminishes, of course, both the strength of the shock and the impulse they would have communicated to

the sail, if their movement had not been interrupted. But this deviation of re-action in the first particles of air which have struck is repeated afterwards. For, all those which succeed them, while the surface is kept obliquely to the wind, continue to re-act to leeward; so that, from the first vertical line, (taken from the windward side,) out of all those which form together the surface, there is a continual series of obstacles which change the flock of immediate and succeeding particles, and which alters it so much the more as they ought to strike the parts of the sail most to leeward, and so much the less as they will strike those which are most to windward. Therefore, the leeward-side of sails, obliquely exposed to the wind, is always less struck than that which stands to windward. Whence it results, that the centre of effort of the absolute impulse of the wind on the sail is lodged in the weather-side of the sail, (for it is supposed to be equally divided in two,) since that is the part which receives more impulsions. Therefore, the centre of effort is also to windward of the centre of gravity of the surface; and the removal of this centre of effort towards the wind is in proportion to the impulse received on the weather-side of the sail and that received on the lee-side. The truth of this assertion is continually demonstrated by daily experience of ships at sea. The sails are carried by the yards and by the masts, which divide them perpendicularly into two equal parts, from top to bottom, through their centre of gravity. When, being placed obliquely to the wind, they are left at liberty, without being confined by their braces or bowlines, they immediately range themselves perpendicularly to the course of the wind, because their weather-side receives more impulse than the lee-side: and there they remain constantly, unless their position be altered; because all their parts are struck equally, and an equilibrium is kept among them; for, the power of the wind, whether it increases or decreases, acts always the same on them all.

This proof, which shews the difference between the centre of gravity and the centre of effort in the sails, requires much attention in the use of that knowledge in practice. For example, in the middle of the yards on their aft-side, there might be fixed a cleat or bolster, which, in oblique courses, pushing them to leeward,

ward, would ease them off from the shrouds, and facilitate their bracing in carrying their centre of gravity, as well as the centre of the absolute effort, a little to leeward; which operation would of course draw that centre of gravity nearer to the axis of the ship, from which it is so essential to remove it as little as possible.

CHAPTER X.

GENERAL OBSERVATIONS ON THE EFFECT OF MORE OR LESS SURFACE OF SAILS EXPOSED, IN VARIOUS WEATHERS, TO THE WIND.

I. WHEN a ship, with a certain quantity of sail, has acquired the utmost velocity with the power which then puts her in motion, it is certain, that, if the surface of the sails is either increased or diminished, the rapidity of the headway will likewise augment or lessen in a very complicated ratio. In order to find out the degree of impulsion of the wind on the sails, multiply their surface by the square of the excess of the velocity of the wind on that of the ship, or, which is the same thing, by the square of the apparent velocity of the wind. Then a second multiplication of that product is to be made by the square of the sine of the angle of absolute incidence, or, in the second case, by the square of the sine of apparent incidence. And this second product will give the degree of the absolute impulse of the wind on the sails, in the actual state which we have supposed.

In order to find in what ratio the surface of the sails is to be augmented to make the ship acquire a certain degree of velocity above that which she possessed under a supposed particular quantity of sail, it must first be known by how much the velocity of the wind exceeds

ceeds that of the ship; then, knowing how many degrees her head-way is wished to be accelerated, the sails must be increased in the ratio of the squares of the two velocities of the ship; viz. that which was known before the alteration of the sails, and that which she is afterwards to acquire. But, as the ship recedes so much the more from the action of the impulse of the wind as her velocity increases, it is evident the surface of the sails must be increased also in the ratio of the square of the two excesses, that is, the different excess of the wind over that of the ship both before and after the increase of the sails; then the ship will acquire the wished-for velocity; provided no other cause happens to oppose it, as we have already hinted before, and as we shall have an opportunity to shew more particularly hereafter.

Suppose the wind has 12 degrees of velocity, and the ship, under a certain set of sails, has 3; the velocity of the wind, in the direct course, will exceed that of the ship only by 9 degrees. If the velocity of the ship is intended to equal the third part of that of the wind, and to have therefore 4 degrees for head-way; then the sails are to this effect to be increased in the ratio of the squares of the two velocities 9 to 16, because the resistance of the water on the bows will increase in that very proportion. But, in the first case, the velocity of the wind exceeded that of the ship by 9 degrees, while, in the second case, it exceeds it no more than 8. Hence it results, that the impulse of the wind on the sails has diminished in the ratio of the two squares 81 to 64; and, in order to repair that loss in the impulsion of the wind, the expansion of the sails is also to be increased in that last ratio of 64 to 81; then the ship will be able to run with the degree of velocity desired.

II. When the masting is perfect, that is to say, when the ship is masted according to the *point velique*, she will rise from the water parallel to herself by a certain quantity relative to her velocity, and she will rise always more and more in proportion as she acquires new degrees of velocity in her head-way. Because she is moved by forces which stand exactly and continually in equilibrium with the action of the water on her bows, the inclination of which forward contributes so much the more to that rising out of the water as it is more remote from the perpendicular.

lar. For, then, the vertical impulsion will have more power, since it acts more directly on a very oblique bow than it would on a vertical one. This reasoning may be as exactly applied to the direct impulsion, the absolute effort of which may be decomposed, since it acts less against the velocity of the sailing on an oblique bow than on a vertical one, while the other part of its action joins with the vertical impulse to raise the head of the ship, which shocks the water with very great strength when she is arrived to a very great velocity, and which water opposes her so much the more as it is shocked with violence. So it is easy to conclude that, in any ship whatever, the more rapid the head-way is, the more parallel to herself she rises above the water, if the centre of effort of her sails is at the same height as the *point velique*: for, the point of the bows, on which may be considered as united the action of the water which opposes its progress, may be taken also as the point of bearing. So that all the sails acting from abaft to forward on different points of the axis of the ship, (she being considered as a lever in the direction of her length,) they raise the after-part of that point, and place it on a level with the elevation of the bows; which never can happen, if the centre of effort of the sails is above or below the *point velique*. If it is placed above, the power of the sails, acting on too long levers, will raise the after-part of the point of bearing of the bows above the level of the elevation of the ship's head. If it is placed below, the power of the sails, acting on too short levers, the after-part of the ship will remain plunged in the water, without being able to rise on a level with the bows. Therefore, in either of these two cases, when the centre of effort of the sails is either above or below the *point velique*, the ship, however well-built, will lose some of the qualities of sailing, either in her readiness to obey the helm, or in her steadiness to carry sail, especially if she is over-masted: for, in this last case, she will gripe, incline easily, and lose much of her head-way, since her bows will plunge in the fluid, or, rather, her stern will rise too much out of it; which will diminish the action of the water on the rudder and increase it on the bows. In the last case, (an inconvenience of which ship-builders seldom, if ever, have been guilty,) the ship will be slow to obey,

obey, and her head-way will be slackened, because she will never present her most advantageous water-lines to the fluid, nor have a sufficient surface of sails, as, although their width is the same, their height is not so. The point of perfection then is this, viz. when the centre of effort of the sails is placed at the height of the *point velique*.

III. The next proposition will appear a paradox to many seamen. But, it is no less self-evident.

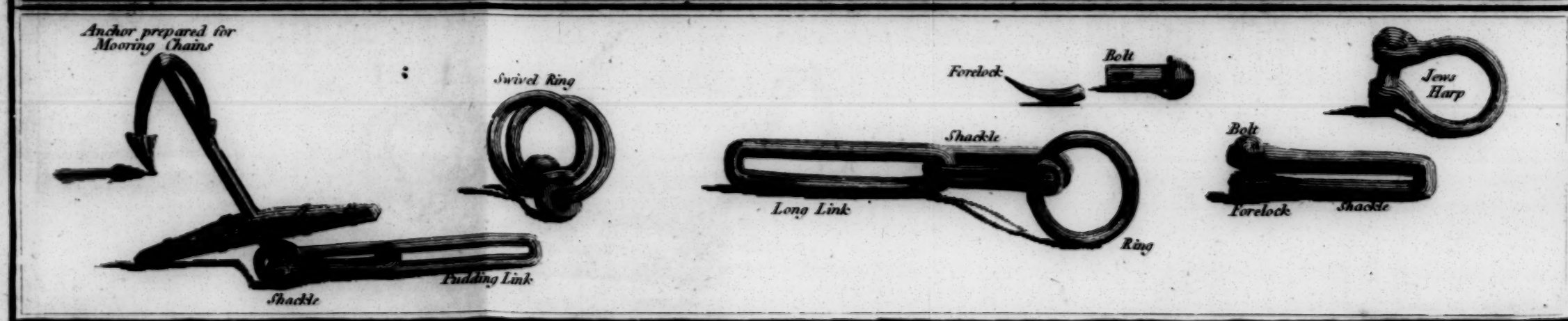
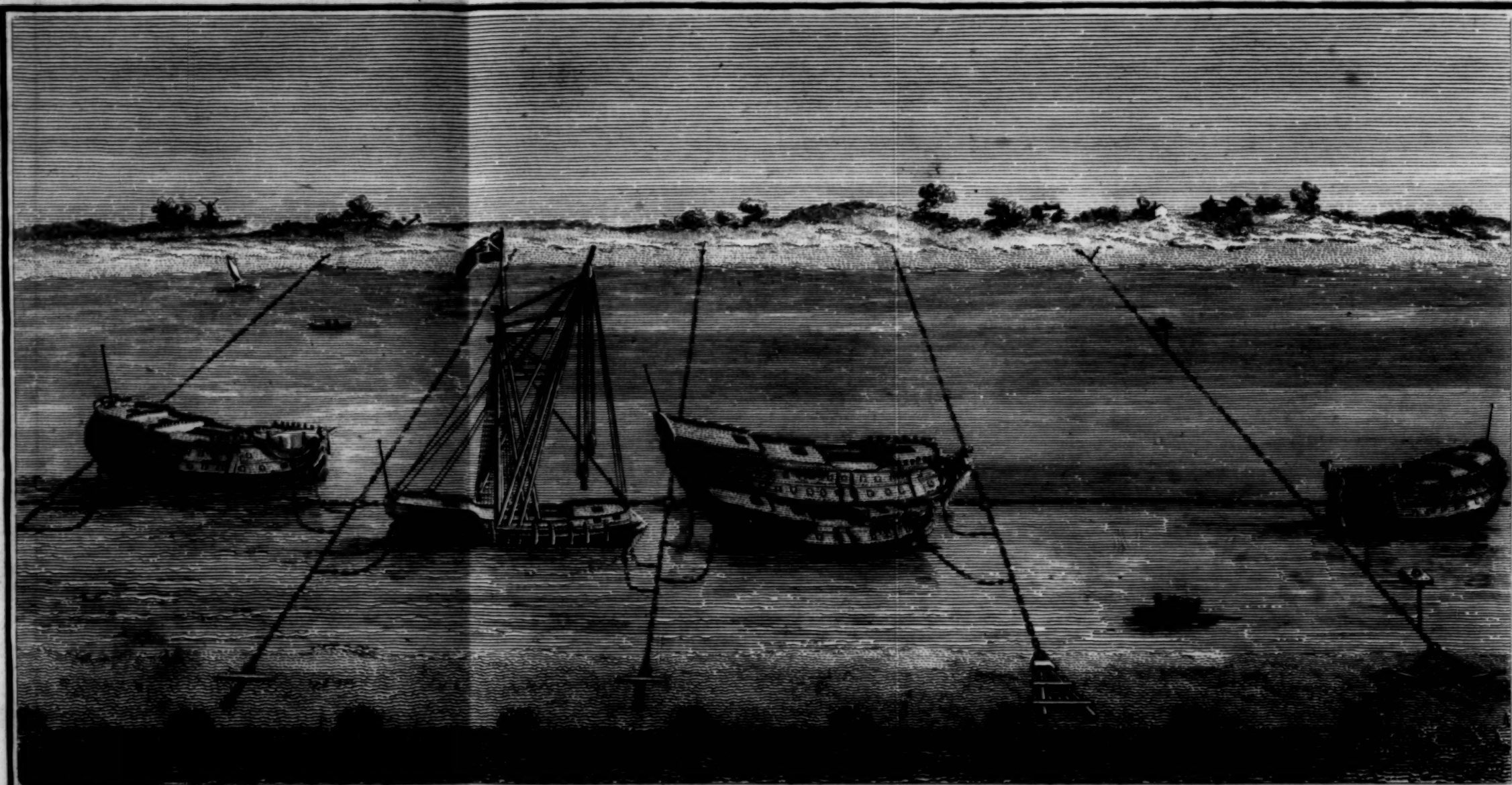
There are many cases in which the adding of a few sails, instead of increasing a ship's velocity, retards it. It is however an error into which all seamen almost continually fall, when, in a strong gale, they want either to distance or approach a ship. When their own ship is arrived to a very great velocity, (sometimes of twelve and more knots an hours,) if they have to do with an adversary the rapidity of which is nearly equal to that of their own ship, they fancy that, by adding more sails to those they have already, at the time when their ship is perhaps best disposed and arrived at its utmost degree of swiftness, they shall increase the rapidity of her head-way; and, accordingly, they hoist up some additional stay or studding sails, especially if the wind happens to be on the beam or a little more aft. But, by this their expectations are baulked; for the ship becomes more inclining, her head plunges, and the resistance of her bows increasing in the direction of the keel more than the effort of the sails in the direction of the course, the rapidity decreases in so much as the water acts more powerfully than the sail does. Besides all this, those forward and lateral inclinations of the ship, produced by the effort of the new-added sail, which have caused the centre of effort of the sails to ascend and the *point velique* to descend, (if the new-added sail has been set above it,) cause also the ship not to rise from the water parallel to herself; she rises her stern and plunges her head; whence it results that she grieves from two causes: first, because, as her stern lies less in the water, the rudder is of course exposed to a less shock; and the stern, which always acts as a sail, is more easily mastered by the wind which strikes it then on the beam with a great deal more efficacy than it does her head: on the other hand, as the resistance of the water on the lee-bow has increased

increased by the inclining of the head, plunging thereby that part of the ship which is the most full in its shape, and increasing also the surface on which the water acts, which has both diminished the head-way and increased at the same time the lateral impulse on the side of the bow; so that lateral impulsion forces the ship to windward more at the head, than she is impelled to fall off by the lateral part of the effort of the new-added sail. Whence it follows that the ship becomes still more griping, which is an additional cause of the decrease of her head-way; because, the helm being more a-weather, in order to hold the ship better to her course, more of the rudder itself is presented to the run of the water; and, by the great surface it offers more directly to its shock, retards the velocity of the ship. Whence we are to conclude that as soon as any more sails are added to a ship which carries already a sufficient quantity of them, she will lose her qualities of steering well and making good head-way, whether those additional sails are set forward or a-stern.

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AREPRESENTATION OF MOORING-CHAINS .



THE PRACTICE OF WORKING SHIPS.

THE useful part of a seaman's duty is the application of his theoretic knowledge to the various evolutions of a ship. We are now about to shew how those various evolutions should be performed, consistently with the principles upon which the science of navigation is founded.

A ship, when launched from the stocks, is furnished with one stream-anchor, and another which is termed a launching-anchor, somewhat heavier than the stream-anchor, hanging by stoppers to the catheads: by one or both of these she is first brought up, and afterwards warped to what are termed

HEAD AND STERN MOORINGS;

of which the following is an accurate description. Across the bottom of the harbour or river, two chains (parallel to each other, if the bed of the river will admit of it) are extended at the distance of 200 feet from each other, by means of anchors, having one fluke only, which is sunk, and secured in the ground by piles, on the opposite sides near low-water mark. To the rings of those anchors these chains are connected by a peculiar sort of link, called a shackle, which is delineated in the plate.

Each of these chains has, at about one-third of its length, a large iron ring, to which is fastened a chain, called an up-and-down span; which, lying on the ground, connects the parallel chains, and serves to keep them steadily in their places. At about 30 or 40 feet distance from each other, along each chain, chain-pendants (from 5 to 9 in number) are fastened, having, at the end which connects with the ground-work, a shackle; and, at the other end, a link called a jew's harp, through which the bridle or hawser of the ship, when moored, is passed. The centre chain-pendant is fixed to the ring of the chain; and the number of the chains must depend upon the number of tiers required, each tier occupying two chains, because the ships are moored head and stern. But every tier does not always occupy two whole chains; because, unless a passage between the tiers is requisite, the chain, to which the head chain-pendant of one tier is affixed, has likewise fastened to it the stern chain-pendant of the next tier. A reference to the plate will elucidate this.

These moorings are calculated for and used in rivers or harbours of small extent; but in other places, where either many ships do not frequent, or the extent of which is considerable, there is another sort in use, called

SWINGING MOORINGS.

These differ from the former only in this; the ground-work being the same, to the ring of the chain is fixed one chain-pendant, the end of which is passed through a large buoy; and to that is connected a swivel ring by a shackle; and thus kept constantly from sinking to the ground. This is used for mooring one or two ships to. Near each end of the chain is fixed one more chain-pendant, supported likewise by a buoy, which is used only for the purpose of warping ships from the middle to any intended place.

OF MOORING TO HEAD AND STERN MOORINGS.

To these moorings ships are thus fastened: Clench the end of a bridle to the jew's harp of the chain-pendant, and pass it into the hawse-

hawse-hole; then heave it up and bit it. Take the after-bridles into the gun-room port, or in upon the quarters; and take a round turn round the beam of the after-hatch, and cross it with a throat and round seizing; or, if more convenient, round the jeer bits.

OF MOORING TO SWINGING MOORINGS.

Pass out the ends of the bridle; one on each side, through the hawse-hole next the stem; then pass them through the swivel-ring of the chain-pendent; then return them into the ship through the after hawse-holes, and bit them.

In this situation a ship is fitted for sea, by regularly stowing her ballast, and getting on board her rigging, stores, &c.

We shall therefore proceed to discuss the theory and practice of ballasting, and shall afterwards treat of the manner of getting on board and stowing the anchors and cables, before we enter upon the method of navigating a vessel in various situations.

OF THE BALLAST AND LADING.

WHEN a ship is loading, it should be considered, that her tendency to pitch or roll depends not alone on her form, but even more upon the more or less advantageous distribution of the heaviest parts of her cargo.

Particular attention is to be paid to moderate her pitching, as that is what most fatigues a ship and her masts; and it is mostly in one of these motions that masts are seen to break, particularly when the head rises after having pitched. Although the rolling be proportionably a more considerable movement than pitching, it is seldom any accident is seen to arise from it, as it is always a slow one. It is however not less proper to prevent it as much as possible. This will in general be easily obtained, without being any way

way detrimental to the ship's stiff carrying of sail, if, when the ballast is iron, you stow it up to the floor-heads; because it will recall the ship with less violence after her having inclined, and it will act on a point but little distant from the centre of gravity. To make this clearer, let us consider it by the assistance of a figure.

First, let it be understood, that the **CENTRE OF GRAVITY** of a body is that point by which it may be suspended, and the parts remain in perfect equilibrium.

That the **CENTRE OF CAVITY** is the centre of that part of the ship's body which is immersed in the water; and which is also the centre of the vertical force that the water exerts to support the vessel.

That the **CENTRE OF MOTION** is the point upon which a vessel oscillates or rolls when put in motion.

That the **METACENTRE** is that point, above which the centre of gravity must by no means be placed; because, if it were, the vessel would overset.

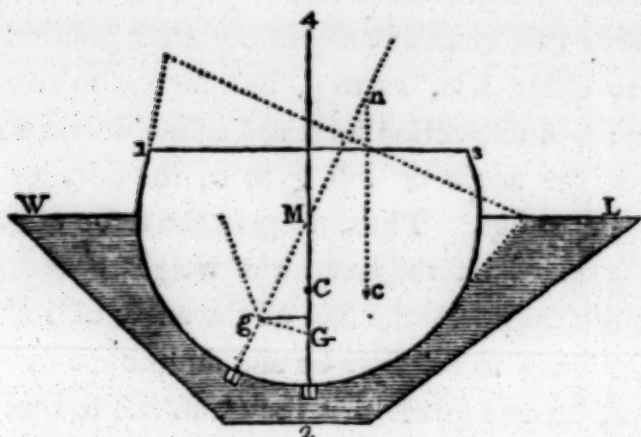
Various methods have been recommended to find all these different points; some of them are in their nature fixed, others varying. Thus, when a ship is completely loaded, the centre of gravity is fixed, howsoever the vessel may alter her position.

The centre of motion is always in a line with the water's edge, when the centre of gravity is even with or below the surface of the water; but, whenever the centre of gravity is above the water's surface, the centre of gravity is then the centre of motion. This must be understood of bodies not perfectly circular; for, if circular, the centre of motion will be the centre of the circle.

The centre of cavity varies with every inclination of the ship, because that depends upon the shape of the body immersed.

The metacentre (which has been likewise called the **SHIFTING CENTRE**) depends upon the situation of the centre of cavity; for it is that point, where a vertical line, drawn from the centre of cavity, cuts a line passing through the centre of gravity and being perpendicular to the keel.

Let



Let the segment of a circle 1 2 3 represent the transverse section of a vessel's bottom; w l, the surface of the water; M, the metacentre, as well as the centre of motion, because this is a circle; c, the centre of cavity; G, the centre of gravity; and the line 2 4, the vertical axis of the vessel which may be turned round the point M, as on a fulcrum supported by the centre of cavity. By thus simply considering the vessel as a lever in the direction of her vertical axis playing round her centre of motion, it is plain, that, if the centre of gravity was placed above the point M, being the metacentre too, the vessel would upset; therefore, that the ship may have stability, the centre of gravity must be below this point. And it may be observed, that, the farther G is removed from the metacentre, the greater must be its force, as the gravity then acts with a greater length of lever, considering the fulcrum of that lever to be at the centre of motion; or, if the weight at G be augmented, it will likewise increase the force; therefore the force of G may be expressed by multiplying the balance of weight, beneath the centre of motion, by the distance of the centre of gravity from the centre of motion.

The centres of cavity and motion (in circular bodies) will ever be in a line perpendicular to the horizon, but the centre of gravity may be either on one side or the other of this line. When such a body is at rest, the centre of gravity will be in this line; but, if in motion, it will be diverted from it. Thus the points M and c will always be perpendicular to w l; but the point G, by the body's rolling, may be on either side; for instance, at g. While G

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is perpendicularly beneath the centre of motion, its action can only tend to *preserve* this circular body in her erect position; but, if it is removed to either side, as to g , its action is to *return* it to the erect position; and this action increases as the distance Gg , which is the sine of the angle of roll gMg , the distance Mg being considered as the radius. Thus, to gain the force of gravity with any roll, as gMg , let the balance of weight beneath the centre of motion be multiplied by the sine of the angle of roll Gg .

But the tendency to roll may be also diminished by the shape of the hull. For, let us suppose that the transverse section be allowed more beam and increased by the dotted lines. Now, when this vessel is rolled over, it is plain that the cavity will be augmented towards the side L , of course its centre must remove towards L , say to c ; and, if from c be erected a perpendicular to the horizon, it will cut the vertical axis at n , which will, in this case, be the metacentre, above which, if the centre of gravity were placed, it would act in conjunction with the centre of cavity to overset the vessel: but, as the centre of gravity is here below it at g , her stability will be increased by the increased distance of G from n , the metacentre; and the vessel will roll round the point M as her centre of motion.

When sailing in smooth water, the greater the stability the better; but, if a vessel with a heavy cargo, stowed low in her bottom, be sent out into a rough tempestuous sea, where every wave will throw her from her equilibrium, she will return with such violence as to endanger her masts; and, should she be dismasted, her roll will then be with still greater force, possibly to the destruction of her hull. Was the cargo in this laboursome vessel to be removed higher up towards the centre of motion, so as to lessen her stability, she would be found considerably easier; her roll would be by such deliberate motions, as to lessen the danger to her masts and hull.

The ballast is placed round and very near the centre of gravity of the ship, because it will prevent the motion of the pitching being so hard as it would, if that weight were distant either afore or abaft that point. Whenever the sea runs a little high, the ship is never carried by a single wave; there are generally two or three

always

always passing under at the same time, unless when the sea is extremely long, the swells coming from a great distance, and in latitudes very remote from land: for, then, it happens that the largest ships are sometimes carried by one single wave. But, in either circumstance, the ballast ought not to be stretched afore or abaft the centre of gravity, as soon as the ship is in the parallel to her draught of water marked for the ballast, which it is absolutely essential to pay attention to. To prove this principle, suppose in either case a long or short surge, and that the water strikes the ship forward, that thereby she may be exposed to the greatest and hardest pitching: for, when the wave takes a ship under the stern, her motions, if she has got a little head-way, are not dangerous; because, as she flies before the wave, she recedes in some measure from its impulse; while, in the first case, she increases on the contrary that same impulse in the ratio of the square of all her velocity.

FIRST, the ship, whose extremities are light or little loaded, being supposed to run with any velocity whatever against the wave which comes to her a-head, shocks that wave with a force expressed by the square of the sum of the two velocities: she divides it and goes through it, at the same instant that she is raised by the vertical impulse of that column of water, which opposes to her a supporting power too considerable for her weight to displace: the wave which follows produces the same effect in receiving the fall of the ship, because the first is already under the middle of the ship, whence it passes to the stern, which is supported by it, while the second takes its place in the middle, and the third is come to support the head; and this is an uninterrupted succession. This motion continuing thus as long as the sea is agitated, it follows that the ship is never at rest: no sooner has she been raised by a wave, but she falls again when that wave is gone, which falling is proportionably less sharp as her head is less heavy: the shake is then less violent, since she shocks the water with a less mass, which prevents her pitching so deep as she would if she were more heavy; consequently the masting does not suffer, and the head-way is less delayed, as the fullest part of the bows is not so much exposed to the shock of the water.

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SECONDLY,

SECONDLY, When the ship is carried by one single wave, her fall is still less sharp, if little loaded a-head, than when she is carried only by the middle. She rises, therefore, more easily at the moment the other wave comes to strike her, and the shake is not so violent. Were she to plunge deeper into the fluid, it might happen that the column of water would become higher than her head, and, passing partly over it, would expose her to the danger of foundering.

In the stowing of the cargo, it is proper to place the heaviest part of the stowage as low as possible, taking care to preserve that draught of the ship which is most advantageous for her, whether she be in ballast or when laden. Those points are marked both at the head and stern: in a word, the great art of stowing lies, in endeavouring that each of the vertical parts, in which the extremities of a ship may be supposed to be equally divided, be lighter, when her lading is complete, than the weight of the mass of water they are to displace; observing always, that the vertical parts of the middle admit of being loaded more heavily than the weight of water they are able to displace.

THE PRACTICE OF STOWING BALLAST, &c.

In the royal navy, the iron ballast is first stowed fore and aft, from bulkhead to bulkhead in the main hold, next to fir cants nailed on the limber-strakes on each side the keelson, five or more inches clear of the limber-boards; and is winged up 3 or more pigs above the floor-heads in the midships, or bearing part of the ship, and there are two tiers of pigs in the wake of the main hatchway and well-wings. Ships, built with a very clean run aft, seldom have any iron ballast stowed abaft the pump-well or after-hold. Ships, that have floor and futtock riders, have the iron ballast stowed, either lengthways or athwart-ships, agreeably to the length of the chambers, which are the clear spaces between the riders.

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The shingle ballast is next spread and levelled over the iron ballast, on which is stowed the ground tier of water; bung up and bilge free from the sides, either chine and chine, or bouge and chine, beginning at the coal-room bulkhead, that being the foremost, and making the breakage, if any, at the main hatch: the midship tiers, fore and aft, are the first laid down, and the casks are sunk about one quarter of their diameter into the shingle; the sides are filled-in with wingers of small casks, as half-hogsheads, gang-casks, or breakers; observing not to raise the wingers above the level of the tier, to cause a breakage in the next tier above, which is stowed in the cunline of the ground tier: bung up and bilge free; and so on, for as many tier as can be stowed sufficiently clear of the beams.

In the after-hold, between the aft-side of the pump-well and fish-room bulkhead are stowed the provisions above the ground tier; between the casks, billet, or other wood, and shingle ballast.

In the fish-room are stowed some of the spirits, or wine, and sometimes coals; and, in the spirit-room, are stowed the wine and spirits for the ship's use.

In the merchant-service, the stowage consists, besides the ballast, of casks, cases, bales, boxes, &c. which are all carefully wedged off from the bottom, sides, pump-well, &c. and great attention paid that the most weighty materials are stowed nearest to the centre of gravity, or bearing of the ship; and higher or lower in the hold agreeably to the form of the vessel. A full low-built vessel requires them to be stowed high up, that the centre of gravity may be raised, to keep her from rolling away her masts, and from being too stiff and laboursome; as, on the contrary, a narrow high-built vessel requires the most weighty materials to be stowed low down, nearest the keelson, that the centre of gravity may be kept low, to enable her to carry sail, and to prevent her oversteering.

By the 19th Geo. II. it is enacted, that if, after June 1, 1746, any master or owner, or any person acting as master of any ship or other vessel whatsoever, shall cast, throw out, or unlade, or if there shall be thrown out, &c. of any vessel, being within any

haven, port, road, channel, or navigable river, within England, any ballast, rubbish, gravel, earth, stone, wreck, or filth, but only upon the land, where the tide or water never flows or runs; any one or more justices for the county or place where or near which the offence shall be committed, upon the information thereof, shall summon, or issue his warrant for bringing, the master or owner of the vessel, or other person acting as such, before him, and, upon appearance or default, shall proceed to examine the matter of fact, and upon proof made thereof, either by confession of the party, or on view of the justice, or upon oath of one or more creditable witnesses, he shall convict the said master, &c. and fine him at his discretion for every such offence any sum not exceeding 5*l.* nor under 50*s.* &c. and, for want of sufficient distress, the justice is to commit the master, or person acting as such, and convicted as aforesaid, to the common goal or house of correction, for the space of two months, or until payment of the penalties.

Besides the above general act relating to ballast, there are the 6 Geo. II. c. 29. and the 32 Geo. II. which regulate the ballasting of merchant-vessels in the river Thames, placing it under the direction of the corporation of the Trinity-house.

MANNER OF GETTING ON BOARD AND STOWING THE ANCHORS AND CABLES.

ANCHORS, though they bear different names on board of ships in the royal navy, as sheet, best bower, small bower, and spare, are of the same weight. The stream and kedge anchors are smaller, and grapnels are for boats.

Ships of 110, 100, 98, and 90, guns, have 7 anchors; from 80 to 20 guns inclusive, 6 anchors; ships of 300 tons and sloops have 5; and brigs and cutters 3 anchors.

In

In fitting out ships, the anchors are brought in craft near the bows, being most convenient to the hawse-holes, through which the cables pass to be clenched.

The BOWER-ANCHORS are first catted; which is performed by hooking the hook of the cat-block into the ring of the anchor, and bowing upon the fall that leads in through a snatch-block on the forecastle; the cat-falls being previously reeved through the sheaves of the cat-head and cat-block, keeping the hook of the cat-block downwards and its point inwards. They are then fished, by means of the half-davit, pendent, and tackle, thus: The davit is first stepped in the channel on the side wanted, and supported by guys: the masthead-guy goes over the end of the davit, with an eye. The other end fastens round the fore-masthead, with a round turn and two half-hitches. The foremost guy goes over the end of the davit, the other end fastens round the cat-head, with two half-hitches, and is securely stopt. The after-guy goes over the end of the davit, and makes fast with two half-hitches, through an eye-bolt in the after-part of the fore channel. At the outer end of the davit is hung, by its strap, a large fingle block; through which is reeved the pendent, with a large iron hook spliced in the lower end, to hook the anchor within the flukes; then, to the inner end of the pendent, is made fast a tackle, by thrusting a toggle through an eye in the block-strap: after that has passed through an eye in the pendent, the other block of the tackle is hooked in an eye-bolt in the fore part of the quarter-deck; the effort of the tackle is communicated to the hook, by means of the pendent, by men's bowing on the tackle-fall. Thus the flukes of the anchor are raised and placed on the gunwale, where it is made fast by the shank-painter chain. That the flukes may lie level, the shock is bowed upon by the anchor-stock tackle, the double block of which is hooked to a selvagee, fastened round the stock of the anchor under the first hoop, and connected by its fall to a fingle block, hooked to a selvagee fastened round the laniard of the main stay: the fall leads in upon the fore-castle.

The BEST BOWER is then placed forward near the bows on the starboard side, the SMALL BOWER near the bows on the larboard side,

side, a little abaft their respective cat-heads, and are secured by their stoppers, from the cat-heads and shank-painters. The stopper has one end clinched round the cat-head; the other end passes through the ring of the anchor, returns upwards, and leads over a large thumb-cleat bolted to the cat-head, and is made fast with several turns, and the end hitched round the head-rail and timber-head, on the fore side of the cat-head. The shank-painter hangs the shank and fluke of the anchor to the ship's side outboard; and, when stowed, the shank-painter is passed under the inner fluke round the shank of the anchor, and made fast with two or three turns, and the end stopped round timber-heads on the fore-castle. With these two bower-anchors ships are generally moored when lying in a tide's way or in a fleet.

The SHEET and SPARE ANCHORS are hoisted by runners and tackles, main stay and yard tackles, and are stowed securely with stock and bill lashings at the after-part of the fore shrouds, before the cheffs-trees on each side of the ship, with one of their arms resting on a chock, bolted to the gunwale; the stock being bowfied-to by the anchor-stock tackle. The sheet-anchor is stowed on the larboard-side, and is the first resource in a gale of wind, after parting with either of the bowers; for which reason, when in port, the sheet-cable is kept bent, and the anchor is over the side, suspended by the stopper and shank-painter, ready for cutting away in case of necessity. The spare anchor is stowed on the starboard-side, and is seldom used, but when one of the others is lost.

The STREAM-ANCHOR is stowed on the spare anchor; and, when used, it is sent in the long-boat or launch, with its cable bent, and let go at any particular spot, either for steadying the ship, when riding by only one bower, or to assist a ship when in shore, or to warp her, &c.

The KEDGE is stowed on the stream and spare anchors, and is frequently used to stop a ship for a tide in little winds; but, if the wind is too powerful for the kedge, the stream-anchor is substituted. The kedge is sometimes used, in moderate weather, to warp the ship so as to shift her birth.

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The CABLES also are brought in craft alongside; and, should they be new from the rope-walk, let them be coiled down in the craft, the same way they are to be coiled on board.

It is recommended to merchant-ships, especially of the smaller size, that their cables should be coiled the way they bit, or the way they run round the windlafs; and their tiers should be on the side opposite to that on which they lead. But this practice cannot be approved of for the royal navy, nor is it indeed there adopted; because, when heaving in upon one cable, and veering out upon another, the cables, by being crossed, are apt to foul in the hatchway. The best bower, which is mostly the working cable, should lead foremost up the hatchway on the starboard-side; then the small bower on the larboard-side; and, afore the latter, the sheet; which, being the least used, can be triced close round the fore-part of the hatchway, out of the way.

A cable generally grinds or kinks from more turns being forced into it by the coiling than it had when first made; and the only way to get rid of those grinds or kinks is to coil the cable across the hatchway, from side to side, in large flakes, with the sun; then take the upper end through the coil, and coil the cable down in the tier the way required. By this means, as many turns will be taken out of the cable as there are flakes coiled round the hatchway.

It should be a rule in coiling cables, never to lay out near the hatchway, but to keep that part of the tier as low as possible, that the bends may have sufficient room to upset.

Were all store-cables first coiled down from the rope-walk against the sun, they would be better adapted to coil on either side of the ship; for a cable coiled against the sun will more easily reverse, and have less grinds or kinks in it than a cable coiled with the sun.

Anchors (except when at sea) should always have a cable clinched to the ring ready for letting go, and a buoy-rope with a buoy.

To CLINCH A CABLE; run it through the hawse-hole and the ring of the anchor three or four fathoms in length; then haul the bight up in the head, and pass the end of the cable over the

the bight, and through the ring, between it and its own part: then pass the cable-bends, and cross them with strands, well greased, one at the end, and the other about one foot from the end; and be careful not to form the clinch larger than the ring of the anchor.

From the MOORINGS a ship, when fitted, removes, in order to take in her guns and proceed to sea; but, before she finally sets sail, she generally comes to anchor, and is moored once with her own anchors and cables, which will be treated of hereafter. At present it is sufficient to give the following caution at

GETTING UNDERWAY FROM RIVER-MOORINGS.

If it be in a tideway and with a leading wind, so that the ship can stem the tide; let it be a rule, when the tide serves, to get underway, and sail against the flood; which gives time to clear a ship of her moorings, and affords a more powerful effect to the helm, to steer the vessel clear of other ships and any particular danger.

PREPARATIONS NECESSARY TO BE MADE FOR ANCHORING.

On approaching an anchorage, the anchor and buoy are got clear, and a range of cable stretched along the deck suitable to the depth of water. Care should be taken, that nothing is in the way to check the cable, or stop its running out: then, at a proper distance, a turn is taken round the bits with the cable, thus: First pass the cable from the anchor underneath the cross-piece, then take up a bight of the cable abaft the bits, and throw it over the bit-head. The end of the cable is clinched round the orlop-beams in the royal navy, and round the main-mast in the merchant-service.

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It is necessary to have water near the bits to prevent its firing by the friction. Stoppers and ring-ropes of all kinds should be ready for use.

The stock-lashing being cast off, and nothing but the anchor-stopper and shank-painter retaining the anchor, men are stationed to stand by them, and let go at the moment ordered.

To secure the cable when out, DECK-STOPPERS are thus previously prepared: They are turned into the ring-bolts on the deck round a large iron thimble, and fastened with a throat and end seizing. Each stopper has a laniard spliced round the head, under the knot, by which several turns are taken round the cable, and the end stopt.

BESIDES the deck-stoppers, others are used as an additional security to the cable; such are the BIT-STOPPERS, &c.

BIT-STOPPERS. Each stopper is reeved through a hole in the standard knee, against the fore-part of the riding-bits, and is turned-in or spliced. It has a laniard spliced round the head, under the knot. When used, several turns are taken with the laniard round the cable, and the end stopt. It is to check the cable in bringing up the ship. Another bit-stopper much approved of is about four fathoms long, and tailed out like a nipper at one end, and knotted at the other. Let this stopper be rove through the hole in standard knee. To pass it, let it be held aft, inside, over the cable, and under the bits, outside the cable; then worm it round the cable before the bits. Then, as the cable runs out and it is required to check the ship, haul tight the worming; and, by the cables drawing forward, it will tighten the stopper, and bend the cable so close to the bits as effectually to bring the ship up. This stopper is not likely to jamb, therefore is extremely well calculated for bringing a ship up with ease; as, by slacking, and hauling tight the worming, the cable may be suffered to run out, or be checked at pleasure.

In heaving up in a heavy sea, when, by a sudden pitch of the ship, the messenger or nippers give way, this kind of stopper will be found extremely serviceable; for, upon these occasions, this stopper may be always passed ready, and the bight triced up abaft the bits with a rope-yarn clear of the cable.

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Another bit-stopper, made with a large eye, that it may be thrown over the bit-head, and shifted over from side to side, is also much approved of.

DOG-STOPPERS. One end is clenched round the main-mast, and the other end wormed in the cuntlines of the cable, and stopt in several places; then brought back with several turns over its own part, and the end stopt. It is of little service, unless it be long enough to clap on above the coamings.

WING-STOPPERS. One end is clenched round the orlop-beams in the wings, and the other end is clapt on as the dog-stopper.

RING-ROPES are occasionally made fast to the ring-bolts in the deck and to the cable, by passing the ends through the ring of the bolt, and through the bight, then clapt on the cable with cross turns, and the ends stopt. Ring-ropes may be better single than double; they are passed with less confusion of turns. To pass a single ring-rope, and have it in readiness to check upon veering away the cable, take also three slack turns through the ring-bolt and round the cable, one before the other, and hold up the parts fair; then take as many slack turns of worming round the cable, before the ring, and they held up fair, leaving sufficient room for the cable to pass through. When the cable is to be checked, haul tight the worming; and, by the cable's running out, it will readily draw the turns tight through the ring, and bind the cable so close to the ring, as to prove an excellent stopper. Ring-ropes are similar to the laniards of stoppers, to check the cable when freshening the hawse, or to add security to the stoppers in a heavy sea.

LENGTHENING OF CABLES. Cables are lengthened by splicing one to the end of the other, thus: The closest and best method is to put the ends in twice each way; then, to pick out the strands, and worm part of them round the cable, and taper away the rest; which should be closely marled down, and a good throat and end seizing clapt on of six-thread ratline.

The strands of the best bower and stream cable had better be pointed, that these cables may be more quickly spliced and unspliced in cases of necessity.

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TO PREVENT CABLES FROM CHAFING by friction in the hawse, and against the stem or cutwater, they are rounded or served thus: They should be served against the lay. The most expeditious way of clapping on rounding is with a top, where room to work it will admit; otherwise it must be beaten on with mallets; and care taken to stop the service with spun-yarn at every six or eight turns.

Mooring-services are clapped on about fifteen fathoms from the end or cable splice. Large vessels should have twelve or fourteen fathoms of service, half of it rounded and the rest plaited and keckled. Upon the best bower or working cable, there should be a short service of eight or ten fathoms at the half-cable.

Mats of the width of the cable's circumference, and about three fathoms long, are very convenient to have ready to lace on the cable with expedition, in cases of necessity, in the way of the hawse or cutwater.

The best service to prevent a cable's chafing is cut from a tanned horse-hide, big enough to wrap two or three times round the cable. The method of putting it on is, first to parcel the cable with two or three turns of old canvas, the length of the leather service; which, if too stiff to put on, only requires dipping in water and beating, which makes it soft and pliable: then pass it tight and smooth round the canvas, and stop it on with fennit or three-yarn knittles, well greasing them, and the service, before veering it into the hawse-hole. Avoid raising the surface of the leather by knittles, &c. underneath the canvas.

OF COMING TO ANCHOR.

A ship ought always, unless under some particular circumstances, to be brought to anchor under an easy sail, such as the three top-sails, jib, or fore-topmast-stay-sail, and sometimes the mizen, according as the vessel has more or less inclination to fall off or come to the wind.

There are, no doubt, cases when more sail may be required; but they are exceptions to and do not destroy the general principle. Nor should an anchor ever be dropt to leeward of the place you mean to bring up in; because that would often occasion a necessity of casting two anchors at once, for fear of dropping still more to leeward.

When the wind is so violent as to bring the anchor home, and make the vessel drive, the cable is veered away; and, in veering away, the turns of the stopper-laniards are slackened, and a portion of the cable suffered to go out of the hawse, to let the vessel farther a-stern of her anchor; in which situation she bears less strain on the flukes, and is less liable to drag the anchor; for, the more cable is out, the flukes become deeper buried, and the ship rides in greater safety.

In letting go an anchor, great care should be taken that the water be not so shoal as to endanger the ship hurting herself upon it, and that the anchor be not fouled by the cable getting about the fluke or stock.

Nor should the water be too deep, because the cable, when out, should approach as near as possible to a horizontal direction. Indeed, this principle is so true, that three cables spliced together, an-end of each other, are kept bent to the best bower-anchor, to be used in cases of necessity; and it is found, that one good anchor, with a long range of cable, is a safer anchorage than two anchors with short cables. However, when the ship has not room to drive, and if the night be dark, let fall a second anchor under foot, with a range of cable above the deck. At all events, the deep-sea lead should be thrown over the gunwale, and the line frequently handled, to be certain that the ship does not drive.

In hard and rocky bottoms, where anchors cannot have much hold, cables are chafed and cut to pieces. When necessitated to anchor in such places, a chain should be run up the cable from the ring of the anchor to a certain distance, to secure it from danger. When a chain is not to be had, (although the top chains may serve,) empty casks well bunged are good substitutes, slung and fastened to the cable at equal distances, to support and keep it from the bottom.

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When ground is soft and oozy, and anchors will not hold securely, but come home with little wind, it is common to cover the flukes with a broad triangular piece of plank much larger than the fluke. Sometimes the anchor is backed, or retained, by carrying out the stream, or kedge, a-head of the anchor the ship usually rides by. In this situation, the bower-anchor is confined by the stream, or kedge, in the same manner as the ship is restrained by the bower-anchor.

In preparing to come to anchor, when the wind is not violent, the topsails ought always to be clued up at the mast-heads; that is, let go the sheets and haul the clue-lines and bunt-lines close up; lower away the topsails and take in the slack of the braces as the yards come down. In this manner you run less danger of splitting and tearing the sails than by any other method.

In all operations hereafter treated of, it should be observed, that whether the wind is moderate or blows fresh, it makes this only difference, viz. The velocity of the ship's movements, in the latter case, being considerably increased, the sails will require an earlier diminution to stop the head-way; and that of course less time in general is taken up in performing every operation.

TO ANCHOR IN FINE WEATHER IN A PLACE WHERE YOU
WILL RIDE HEAD TO WIND, BEING CLOSE-HAULED.

Being under the three topsails, fore-topmast stay-sail, and mizen, stand on until you are within about two ships' lengths of the place where you mean to drop your anchor; then put the helm a-lee, and haul down the fore-topmast stay-sail. As soon as the topsails shiver, clue them up briskly, before you lower; except the mizen topfail, which is to be laid to the mast, and the mizen sheet hauled flat aft, the instant the ship begins to have stern-way, by reason of the wind being a-head. Then shift the helm to windward, and
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let go the anchor, veering away the cable, to give it time to settle in the ground, until the vessel falls off, when she is to be checked, to bring her head to the wind. When that is done, right the helm, and haul up the mizen.

DEMONSTRATION.

The ship is hove up in the wind by hauling down the fore-topmast stay-sail (§. 31) when nearly two ships lengths from the spot where the anchor is to be dropped, because the head-way is sufficient to shoot her that distance; and as, by this movement, the ship is generally found to stop a little to windward of the place where you mean to bring up, you wait till she begins to go a-stern a little before you let go the anchor, and the helm is at the same time shifted hard over the other way (§. 58) to moderate the ship's falling off when she is head to the wind. The topsails are clued up as soon as they begin to shiver, not only because it can at that time be done easily, since they come in of themselves as they lower; but because, if delayed longer, the stern-way would become too rapid, since the sails would be all a-back, and would soon drive the ship to leeward of her intended anchorage. Besides, the celerity of her falling off would be such, as to cause her to drag the anchor before it had got a proper hold of the ground; and that is the reason why the cable is veered away in order to give the anchor time to sink into the bottom by its weight. The mizen top-sail is braced perpendicular to the keel; because, in that situation, the ship is impelled (§. 36) a-stern exactly in the direction of her keel. The mizen sheet is hauled flat aft, to bring the ship's head sooner to the wind; (§. 40;) and, as soon as she arrives at that point, that sail shivers; in which case it is immediately brailed up, as being no longer of use. The helm is righted, having no longer any power; since the vessel is now brought up, and all the sails are furled, except the mizen top-sail, which is flat a-back to the mast, to keep the ship steady at her anchor.

TO ANCHOR IN FINE WEATHER IN A PLACE WHERE YOU
WILL RIDE HEAD TO WIND, THE WIND BEING LARGE.

If you have the wind large, whether on the beam or more aft, the operation is still the same, only hauling up a little sooner to keep to windward, because it is in your power to drift as much as you think requisite, and because the ship will be entirely stopped as soon as all her sails begin to catch a-back, and you will have done cluing them up when they begin to shake. The mizen top-sail is next to be heaved to the mast, the helm put a-weather, (§. 58,) and the anchor let go, as soon as the head-way ceases: then, after giving her a sufficiency of cable, bring the ship up. If she has been going large, she will not range precisely head to wind, since her headway ceases as soon as the sails are taken a-back, and the effort of the wind acts on all the rigging of the ship to impel her both a-stern and to leeward, which is indeed augmenting the effect of the rudder, as the helm is a-weather to bring the vessel to the wind: (§. 58:) but, as the power of the wind is very great to pay the ship's head off, it balances wholly or partly (according as the ship goes a-stern with more or less velocity) the effort of the rudder and that of the mizen: thus she drifts, and remains as it were lying-to with all her sails a-back. This is the reason why we keep a little to windward, and let go the anchor, to bring the ship head to wind at the proper time; which she will do the more readily as she is withheld forward only by the cable, while the wind on her side forces her to leeward.

TO ANCHOR IN FINE WEATHER IN A PLACE WHERE YOU ARE TO RIDE HEAD TO THE STREAM AND WIND, THE WIND BEING LARGE.

If you are obliged to ride with the head to the stream, you must, when it comes from to windward, put the helm a-lee in setting the mizen, then clue up the sails; and, when the ship's head is right in the direction of the stream, let go the anchor, provided she has quite lost her head-way; for, else, you would get foul of the anchor-stock by running over it. This must never be neglected, unless you find yourself under the necessity to bring up in any situation in which you may happen to be, which is almost always the case when you are taken too short to have time to stop the vessel: a reason why there is often a necessity of casting a second anchor, which generally catches the ground by assistance of the first, which has begun to diminish the velocity of the ship; and as many of the sails are to be hauled down as you can, and as quick as possible.

TO ANCHOR IN FINE WEATHER IN A PLACE WHERE YOU WILL RIDE HEAD TO THE STREAM, WHICH COMES FROM LEEWARD, THE WIND BEING LARGE.

When the current comes from to leeward, you must keep the ship away till her head comes to the set of the stream, and take in all the sails, to diminish as speedily as possible her head-way, which always continues of itself long enough when the wind is aft or very large; and when the ship is stopped by the effort of the water, let go the anchor, without waiting for the vessel gathering stern-

stern-way, if the current is rapid; and, in this case, as well as all those wherein there is a sea, or blowing fresh, the ship requires a great length of cable.

TO COME TO AN ANCHOR WITH THE WIND AFT.

First, hand the main topfail, and then lower the fore topfail down on the cap; and, when you are within a reasonable distance of the place where you mean to drop anchor, (which distance is to be judged of from the readiness of the ship to obey the helm, and from her velocity,) the tiller may be put either one way or the other, (§. 50,) the fore-topfail and fore-topmast stayfail clued up and taken in, the mizen-topfail braced sharp up, and the mizen-sheet hauled flat aft. When the ship ranges close to the wind, she is, as it were, lying-to under the mizen and mizen-topfails, with the last-mentioned sail full or a-back, according as you may have occasion to shoot a-head or drop a-stern; so that, if you are too much to windward of the spot where you mean to bring to, you drift till you arrive at it: if you are precisely in the proper birth, you let go the anchor in lowering down the mizen-topfail, which is to be furled as soon as the vessel is brought up; then the ship will come head to wind by the power of the mizen, which must be brailed up as soon as it shakes.

DEMONSTRATION.

The main-topfail is taken in, and the fore-topfail lowered down, to diminish the great velocity which a ship commonly has when the wind is aft, in order to estimate the distance with greater precision, and to have her movements more under command. When you think yourself at the necessary distance the ship requires to stop close-hauled, at the place you wish to anchor, you put the helm on board one way or the other (§. 50)*; you brace sharp the

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mizen-

mizen-topfail for the tack you haul upon, (§. 41,) and haul the mizen out to bring the ship rapidly to the wind. (§. 40.)

In the same moment, the fore-topfail is to be clued up and handed, and the fore-topmast stayfail hauled down, because they oppose the movement of the ship (§. 31, 32, and 33) as she is coming to. When you are close to the wind, the anchor is let go, if you are in the birth you wish: if still too far to windward, you can drift, keeping the mizen-topfail full; and, when you are to windward, should you find yourself too far a-head, lay the mizen-topfail a-back, to go a-stern, (§. 44,) putting at the same time the helm a-weather. (§. 58.) When the vessel has drifted sufficiently, let go the anchor, and furl the mizen-topfail; because the cable might be injured, should it blow fresh: then the ship will soon range head to wind, though the mizen be still out; (§. 40;) and, when that is attained, the mizen is brailed up to prevent the ship sheering; and the helm is righted for the same reason.

In some cases you are obliged to come to an anchor with the wind aft, standing end-on, because there is not always a space necessary to deaden the ship's way. In this situation the sails are to be taken in as soon as possible, in order to lessen the velocity of the ship. When come to your birth, let go the anchor, and veer away the cable plentifully, that the anchor may have time to take the ground; then begin to check her gently, veering still more cable as the ring-ropes or stoppers, placed on it before-hand, break away; for they should be permitted to break, in order that you may not be exposed to drag your anchor, by bringing the vessel up at once.

SCUDDING UNDER A FORESAIL, TO COME TO AN ANCHOR.

The foresail must be clued up when at some distance from your birth; and, some part of the way, run under bare poles. When near enough to sheer to the wind, you execute it by putting the helm hard a-lee; and, as soon as the ship is come-to, let go the anchor, giving her a large scope of cable, and observing to check her handsomely, in order to make her ride head to wind: as stopping her at first too short might very well endanger her cable or anchor. Should the first not bring her up, a second may be let go.

DEMONSTRATION.

As you cannot run for an anchorage under a foresail, unless before the wind, or very free, you are necessarily obliged to furl that sail at a great distance; because, in that position, the velocity of the ship will, by the violence of the wind, be but too much kept up, so as to make you run the rest of the way, which may perhaps be a quarter or half a league, under bare poles, the wind being nearly aft. If you were obliged to run at that distance close-hauled, you would never reach your birth, should the foresail even be set; because the ship would be laid-to, as was shewn before. You put your helm over to sheer to windward when you think you are at the necessary distance, that you may have time to deaden the ship's head-way: and as, when she stops coming to, her head-way ceases, you let go the anchor, and veer away a great extent of cable; because, when it blows hard, there is commonly a great swell, and the pitching motion it gives to the ship, joined to the effort of the wind on the rigging, would bring home the anchor. You are therefore obliged to veer away a great length of cable, to give the anchor time to settle, and to cause the cable to make a very acute angle with the ground, by which the strain is much reduced.

TO ANCHOR WITH A SPRING, IN ORDER TO PRESENT THE VESSEL'S SIDE TO A PLACE OR SHIP YOU WISH TO CANNONADE.

This is executed when you know that the wind or current will bring your head, when at anchor, towards the object you mean to attack: for, should the wind or tide bring your broad-side to bear on the object you mean to cannonade, the spring would only be a precaution, to get under way more quickly in case you were obliged to retreat, or in case the wind or tide should shift.

Get a large snatch-block in the aftermost port, on the same side you wish to present to the wind or current, and on the same side with the anchor and cable with which you mean to bring up; then, through the block, reeve a hawser, the end of which is to be clinched to the ring of the anchor you mean to let go; the other part is brought to the capstern, with necessary ranges of the cable and hawser on deck. That done, and the ship being arrived at the birth, you are to deaden her way according to circumstances: you let go the anchor, and veer away enough cable and hawser, now a little more of the one, and then a little more of the other, according as you wish to present more head or stern; which you can do by heaving on the spring, or, what is the same, veering away more cable. Should you find it requisite to shift your position, you have only to veer out more of the hawser.

TO COME TO AN ANCHOR IN ROADS THAT ARE OFTEN CROWDED WITH SHIPS, AND TO LEAVE CLEAR BIRTHS FOR OTHERS.

The best anchoring-births in these places are mostly known by marks, and of course are occupied by the first ships.

In

In a tide or trade-wind roadstead, the next ship that comes should not anchor right a-head or a-stern of the first ship and so as to lie in the other's hawse, but should come-to on the bow and quarter at a sufficient distance to prevent other ships from coming between, and in a slanting direction from the tide or wind. This might contribute to the safety of ships when it blows strong upon a lee-tide or in strong sea-breezes, as each single ship may then veer away what cable necessary, and keep clear of the other ship's hawse a-stern; or, in case of driving or casting, they have a better chance of keeping clear of each other.

A good anchoring-birth in a crowded roadstead is obtained by first running down through the middle of the fleet, and taking notice where a good birth is left vacant by some ship that has failed from the middle of the fleet; then steer out from among the ships, and turn to windward so far, as to give time to take in and furl all the sails, and run down before the wind amongst the ships without any sail, and let go the anchor at the intended birth.

TO COME TO AN ANCHOR WITH THE WIND ACROSS THE TIDE.

The ship should, if possible, be put upon the tack that stems against the tide when the anchor is let go; and, if it be designed to continue at a single anchor, in order to keep it clear, sheer the ship and keep her to leeward of the anchor, by keeping the helm a-weather and the fore-topmast stay-sail set, with the sheet to windward.

Much benefit may result from letting go the anchor stemming against the tide, especially with a rapid tide; for it gives an opportunity to observe at what rate the ship drives a-stern, so as to judge whether it may not be necessary to keep sail set, in order to bring the ship up to ride easy in a rapid tide, and keep her clear of shoals, &c. a-stern.

TO

TO COME TO AN ANCHOR WHEN THE WIND IS RIGHT AGAINST THE TIDE, THE SHIP DRIVING WITH THE STRENGTH OF THE TIDE AGAINST THE WIND.

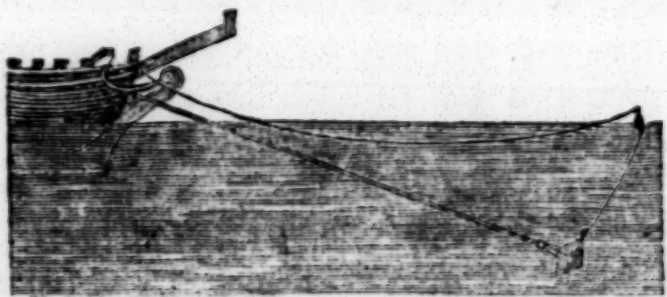
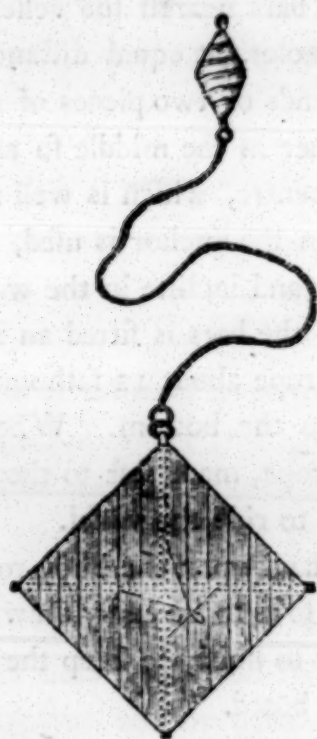
Shoot the ship a-head of her anchor, or sheer her clear of it, upon the same tack as she is meant to shoot upon the next tide, always endeavouring to keep the ship, in swinging with the tide, on one side of the anchor, to clear it. Suppose that the ship, driving to windward, has got to an anchoring-birth, or that the tide is so far spent that she will drive no farther to windward, and must come to an anchor on the starboard-tack. In letting go the anchor, the ship should be shot a-head of it, and kept a-head with the helm a-weather, the yards braced full with the larboard-braces, the fore-topmast stay-sail and mizen set full, till the windward tide is done; then she falls to leeward and rides windroad, with the wind and anchor right a-head; in which position she will lie clear of the anchor till the next windward tide.

TO COME TO AN ANCHOR WITHOUT TENDING.

If it happens that a ship is to be brought up in a place where there is not sufficient room to tend her, reduce her head-way as much as possible before she comes to her anchoring-birth, so that a less scope of cable will bring her up.

DESCRIPTION

DESCRIPTION OF A FLOATING ANCHOR TO RIDE BY IN A
GALE OF WIND.



This simple machine is made to dive beneath the swell of the sea, and retain the vessel where there may be no other anchorage.

It consists of two flat bars of iron, each in length half the breadth of the midship-beam of the vessel for which it is used, and rivetted

rivettted together in the middle by an iron saucer-headed bolt, clenched at its point, that they may be swung parallel to each other for easy stowage. At each end of the bars is a hole for a rope, or swifter, to pass through, which must be hove tight, to extend the bars at right angles. To this swifter is marled a double or four-fold canvas cloth, made of N^o. 1, of the same shape, so as to be on that side of the iron bars nearest the vessel when used.

In each bar are two holes, at equal distances from the centre; and to these holes the ends of two pieces of rope are fastened: the ropes are seized together in the middle so as to form a crowfoot, having an eye in the centre, which is well served with spunyarn, and to this is bent, when the anchor is used, a cable or hawser, by which it is made to sink and incline in the water.

In the end of one of the bars is fitted an iron ring, to which a buoy is made fast, by a rope about 12 fathoms long, to prevent the anchor from sinking to the bottom. When it is thrown over-board, the cable and a rope, made fast to the head of the buoy, are veered away sufficiently to ride the vessel.

To get it on board, haul upon the buoy-rope, which will bring it to the water's surface so as to be easily drawn to the vessel. Have the mizen-stay-sail ready to hoist, to keep the vessel to the wind till the anchor is hauled on board.

INSTRUCTIONS

INSTRUCTIONS FOR THE MANAGEMENT OF SHIPS AT SINGLE ANCHOR.

OF SHEERING A SHIP.

If the side of a ship at anchor is presented to the tide by any means, the water will act upon her two ways; one in the direction of her keel, the other in the direction of her beams; the last will cause her to sheer out to one side of her anchor, which was a-head before. Suppose, for example, the power which presents the ship's side to the tide to be a spring; from the anchor coming in aft on the starboard-side upon heaving in the spring, the ship will sheer over to port, bringing the anchor upon the starboard-bow: the more the spring is hove in, the more the ship will go a-head, and over to port, until her side makes an angle with the tide of 45 degrees, as the farthest she can go over from her anchor: for the spring hove in after this will cause the ship to return, and be in the stream of her anchor when she is hove round a broadside to the tide. Now, if the helm is put over to starboard, it will act as the spring, by forcing the ship's stern to starboard; and thus, by causing the water to act upon her starboard-side, the ship will be forced over to port: on the contrary, had the helm been put to port, the larboard-side would be presented to the action of the water, and the ship will go over to starboard; but the power of the rudder being according to the strength of the tide, its action lessens upon the rudder, as the ship sheers obliquely to the stream, and cannot produce so great an effect as the spring.

RIDING AT ANCHOR IN MODERATE WEATHER.

When riding in a tideway with a fresh wind, the cable should have a short or windward service, of about 45 or 50 fathoms from the manger-board outwards, always sheered to leeward, (not to windward, as thought by some,) not with the helm hard down constantly, but more or less so, according to the strength or weakness of the tide. Many ships have sheered their anchors home, driven on board other ships, or on sands near which they rode, before the anchor was discovered to have moved from the place where let go.

TO BACK A SHIP.

When the wind is cross, or nearly off shore, or in the opposite direction, ships will always back by the mizen-top-sail, assisted if necessary by the mizen-stay-sail. If no mizen-top-sail, the main-top-sail is used.

In backing, always keep a tight cable to wind the ship, that the anchor may be drawn round. If the wind is not sufficient for this purpose, the ship must be hove a-peek.

OF BRACING THE YARDS.

Riding with the wind afore the beam, brace the yards forward: if abaft the beam, brace them all a-back.

OF RIDING WHEN IN DANGER OF BREAKING THE SHEER.

If the wind is so far aft that the ship will not back, she must be set a-head; but never attempt to back, if, when the tide ceases, the ship forges a-head, and brings the buoy on the lee-quarter. If the wind is far aft and blows fresh, the greatest attention is required; as ships, riding in this situation, often break their sheer and come again to windward of their anchors; to prevent which, the after-yards must be braced forward, and the fore-yards aft: thus she will be safe, so long as the buoy can be kept on the lee-quarter; or, suppose the helm to port, so long as the buoy is on the larboard-quarter. With the helm thus, and the wind right aft or nearly so, the starboard main and fore braces should be hauled aft if led aft, and forward if they lead forward.

HOW TO MANAGE A SHIP WHEN HER SHEER IS BROKEN.

If the ship tends to leeward, and the buoy comes on the weather-quarter, and she breaks her sheer, brace about the main-yard quickly; if she recovers and brings the buoy on the lee or larboard-quarter, let the main-yard be again braced about; but, if she comes to her sheer the other way, by bringing the buoy on her starboard-quarter, change the helm and brace the fore-yard to.

OF TENDING TO LEEWARD WHEN THE SHIP MUST BE SET
A-HEAD.

When the ship begins to tend to leeward, and the buoy comes on the weather-quarter; first brace about the fore-yard; and, when the wind comes near the beam, set the fore-stayfail, and keep it standing until it shivers; then brace all the yards sharp forward, especially if it is likely to blow hard.

It sometimes happens that, when the fore-stayfail is set too soon, the ship's head will pay round off, and she will break her sheer: to prevent this, and to keep the wind broad upon the beam, it will often be necessary to set the mizen-stayfail also; which should be hauled down as soon as the wind comes before the beam, otherwise the ship's head will be thrown in the wind too soon.

WHEN THE SHIP IS LIKELY TO GO TO WINDWARD WITH
A LONG SERVICE OUT.

Riding leeward-tide with more cable than the windward-service, and expecting the ship will go to windward of her anchor, begin, as soon as the tide eases, to shorten in the cable. This work is sometimes hard, but very necessary; otherwise the anchor may be fouled by the great length of cable the ship has to draw round, or the cable would be damaged by the bows and cutwater.

When a ship rides windward-tide, the cable should be *keekled* from the short service towards the anchor, as far as will prevent its touching the cutwater.

When the ship tends to windward, and must be set a-head, hoist the fore-stayfail as soon as it will stand; and, in moderate weather, the

the jib also; and, when the buoy comes on the lee-quarter, haul down the fore-stayfail, and jib, if set; brace-to the fore-yard, and put the helm a-lee; for, till then, the helm must be kept a-weather, and all the yards full.

TO MANAGE IN A STORM.

When the ship rides leeward-tide, and the wind increaseth, give her more cable, otherwise the anchor may start by not doing so in time, and the ship will not easily be brought up again: this is the more necessary when riding in the hawse of another ship. Previously to giving a long service, it is usual to take a weather-bit, or a turn of the cable round the windlass-end, that, in veering away, the ship may not overpower you. Grease the service, to prevent its chafing in the hawse.

If the gale increaseth, the topmasts should be timely struck, but the fore-yard seldom, if ever, should be lowered down, that, in case of parting, the foresail may be always ready. At these times, let there be more people on deck than the usual anchor-watch, that no accident may happen from inattention.

TO TEND A SHIP FOR A WEATHER-TIDE.

A ship riding at anchor upon a lee-tide, with the wind in the direction of the tide, requires, upon the tide's setting to windward, to tend clear of her anchor: for this purpose, when the weather-tide sets, and brings the wind broad upon either bow, hoist the jib and fore-stayfail, and brace full the yards to shoot the ship a tight cable

cable from her anchor: then put the helm a-lee, and wait until the buoy comes upon the lee-side: this done, brace to the head-yard, and keep the after-yards full to assist the helm. If the buoy bears nearly a-beam, the jib and fore-stayfail may be hauled down; but, if the wind is fresh, and shoots the ship nearly end-on with the cable, bringing the buoy upon the quarter, keep up the fore-stayfail; as, in this situation, the ship will be in danger of breaking her sheer against the helm; and the fore-stayfail will be ready to catch her before she can fall to windward of her anchor. As the weather-tide slack, the ship will gradually fall wind-road; then haul down the fore-stayfail and right the helm: should it blow fresh, let the yards be braced forward, and give the ship sufficient cable.

TO TEND A SHIP WITH THE WIND A FEW POINTS ACROSS
THE TIDE.

If a ship riding at anchor upon a lee-tide, with the wind two or three points upon the bow, is to be cast for a weather-tide; when the tide is done, the ship will become wind-road, and of course must cast with her head to the weather-shore. As the lee-tide makes and brings the wind on either side, put the helm a-lee, hoist the jib and fore-stayfail with the sheets to windward, brace a-back the head-yards, and fill the after-yards. When the ship has sheered tight to windward of her anchor, haul down the jib and fore-stayfail; and, as the wind is broad upon the quarter, she will lie quiet the remainder of the tide. As the weather-tide slack, the ship will shoot end-on with the cable, bringing the buoy upon the weather-quarter. When the wind is a-beam, if it is thought necessary, the jib and fore-stayfail should be hoisted to force the ship a tight cable from her anchor; and hauled down when they shiver. Should it blow fresh, give the ship sufficient cable before the lee-tide makes, and point the yards to the wind.

TO TEND A SHIP WITH THE WIND ACROSS THE TIDE.

The simplest way of tending a ship, is to keep each tide to leeward of her anchor. At each slack water the ship will become wind-road; and, as she tends, and brings the wind on either side, put the helm a-weather, and hoist the fore-stayfail with the sheet to windward, to force the ship a tight cable from her anchor. When the tide is set, and the ship upon a proper sheer to leeward of her anchor, the fore-stayfail may be hauled down.

GENERAL OBSERVATIONS UPON SHIPS AT SINGLE ANCHOR.

If at any time the anchor-watch should wind the ship, or permit her to break her sheer, the anchor should be hove in sight immediately, or on the first opportunity.

When lying in a roadstead, the anchor should be hove in sight once a week, though there be no suspicion of its being foul, for sometimes the cable is damaged by sweeping wrecks, or lost anchors, or from rocks or stones. It is often needful to trip the anchor, to take a clearer birth, particularly when any ship brings up too near; but, if there is the least suspicion of the ship's having come near her anchor, it should be fought the first opportunity.

A good roadstead is much better than a bad harbour, and more safe: therefore never leave a good roadstead for the latter, without real necessity, which can only be when you can ride no longer, and have no lee-road to fly to.

There are roadsteads where an anchor will bury itself, so that the bight of the cable cannot foul it. In such places, where there is room, it is better to lie at single anchor than to moor.

If

If it is possible, always shoot a ship on the same side of her anchor each tide, to prevent danger from the anchor's not turning as the ship swings; for the anchor, by not turning in the ground, endangers fouling the cable round the upper fluke or stock, which will either trip the anchor or damage the cable: and it often happens, when an anchor is tripped out of stiff ground, that it will not take hold a second time, without the upper fluke should cant down; for the quantity of clay sticking to the fluke prevents its setting into the ground again: so the anchor keeps tripping over the surface, and another anchor must be let go before the ship can be brought up. As a ship, by being sheered, presents one bow to the tide, if the wind is against the tide, it must blow upon the opposite quarter.

It is not always necessary to use the yards, in tending a ship, to shoot her a tight cable from her anchor. In general the jib, fore-stayfail, and main-topmast stayfail, will be sufficient for the purpose. Should the wind shift at any time, it will be necessary to alter the sheer of the ship accordingly.

ON MOORING.

When a ship is come to anchor in a place where she is intended to remain, prudence dictates that she should be well secured. For this purpose the putting down additional anchors is calculated, and has been denominated **MOORING**. The various situations of places, settings of tides, &c. occasion the necessity of the following particular directions.

When the best bower is gone, and about two cable's length is run out, the small bower is let go; and, when that has taken the ground, you heave in one cable's length upon the best bower, and veer away a cable's length of the small bower; and thus the ship is kept at an equal distance between both, the one lying to the head, and the other to the stern.

In roads where there is much tide, and freshes are expected, ships moor according to the set of the current, one anchor riding to the flood, and the best anchor and cable to the ebb.

In roads where there is little or no tide, ships moor according to the set of the most prevailing wind on the coast.

It may so happen, according to circumstance and situation, that the vessel must ride by a greater scope on one cable than the other, but still the manner of letting go the anchors is the same.

Another method of mooring is, by carrying the last anchor out in a boat to the place appointed, and there letting it go. Steadying or mooring with a kedge is usually done in this manner.

OF MOORING WITH TWO, THREE, OR MORE, ANCHORS A-HEAD.

This is done by letting go the number of anchors necessary, and veering away; this being no ordinary practice, but only adopted in cases of danger and peculiarity of circumstance; time, place, and situation, must be the only guide to such an operation: as one instance, suppose a ship cannot clear the shore under her lee by sailing, owing to a strong wind and high sea, the only resource is to let go all the anchors to the best advantage. For this purpose, let the cables that are bent be got clear for running. Then furl all the square-sails as quick as possible, and shoot the ship along the shore under the stay-sails. When the square-sails are furled, let go the weathermost-anchor, and veer away the cable quickly; then let go the next weathermost, and so on, till all the anchors are gone nearly in a line along the shore: thus, when the ship becomes wind-road, all the cables may be made to bear an equal strain, and are separated from each other.

 TO BACK AN ANCHOR.

To back an anchor is to let go a small anchor a-head of a large one, to which it is fastened, to partake of the strain, and to serve as a check upon it, should it come home.

The backing-anchor is carried out in a long-boat, to the buoy of the one already down, whose buoy-rope is cast off and bent to the cable or hawser of the backing-anchor; that done, the boat is rowed farther a-head, till the buoy-rope and cable of the backing-anchor become tight, when it is let go, the buoy that was taken from the large one being previously bent to it.

In

In this situation, should the large anchor come home, the scope of cable from it to the anchor a-head, participating of the strain communicated to the innermost one, checks its progress, and ensures to the vessel a greater security.

Where there is more room to drive without danger, and it blows so hard, that the sea runs too high for boats to work, an anchor is backed by clenching, round that part of the cable next the hawse-hole, the end of a cable bent to another anchor on board. This being done, the second anchor is let go under foot; the ship is then suffered to drive, and the cable, by the driving of the ship, becomes tight from the ring of the anchor last down to its own anchor, which, by the driving also, is now become a cable's length a-head of the former anchor.

TO MOOR IN A TIDE'S WAY.

To bring a ship up at high water, with an intention to moor with the best bower to the ebb, let go the best bower, and bring her up with the cable stoppered, until the ebb makes strong; then veer away two cables; and, if possible, assist her a-stern with the mizen-topfail. If, when two cables are out and the ship in the stream of her anchor, it is thought, when moored, she will ride too near any other vessel, sheer her over from that vessel, and let go the small bower-anchor; then ship the capstern-bars, bring-to the best bower, veer away the small bower, and heave in the best bower to the whole cable-service; then bit and stopper the cables, leaving sufficient service within board to freshen the hawse.

TO MOOR WITH AN OPEN HAWSE TO ANY PARTICULAR
QUARTER.

Suppose, for example, the roadstead or river, intended to moor the ship in, to lie north and south, (in which direction the anchors are to be laid,) and that her best bower is carried on the larboard-side, and it is meant, when moored, the ship shall swing with an open hawse to the eastward. In this case the best bower must be the northern anchor; but, if the hawse had been required to be open *when her head was swung* to the westward, the best bower must have been the southern anchor.

HOW THE WEAKEST MOORINGS MAY BE BEST APPLIED TO
HELP A SHIP TO RIDE OUT A STORM.

It may happen that the small bower cable may be too much worn, or the small moorings known to be too weak, to ride a ship out a storm, when the anchor at the best cable is in danger, or expected to come home. In this case, to make the weak moorings serve for a backing to the best anchor and cable, contrive a traveller, of sufficient sized rope to go slack round the best cable, without the hawse, and well secure it with rolling hitches seized to the weak moorings, that may be veered away, or let go, as occasion may require; if short of rope to make a proper traveller, a large stopper may be clapt on without the hawse, till the end of the small moorings is fastened round the best bower cable, with a bowline-knot open enough to slide along the best cable, until it comes to the ring, which may prove such a sure backing, as to prevent its coming home.

OF KEEPING A CLEAR HAWSE.

When a ship is moored, she is often thought to be in such a state of security, that the keeping a clear hawse is too often neglected.

If the hawse is clear, the ship must ever swing with her stern to the side on which the headmost cable leads.

If, to keep a clear hawse, the ship should swing with her stern to windward, it will be impracticable to get her the right way by any sail that can be set; for, as the tide slackens, she will fall windward; and, when the tide sets, it will take her upon the wrong side. However, if the wind continues, she cannot foul her hawse any more, as, at the next tide, the same wind will undo the cross it caused. When the wind is either a-head or a-stern, by the assistance of the mizen-topfail or jib, the ship can mostly be made to swing the right way. For example, suppose the wind a-head, or even a little upon the starboard-bow, and that the ship's stern is to swing to starboard: in this case, set the mizen-topfail, with the starboard yard-arms braced forward, haul up the starboard-bowline, and hoist the jib with the sheet to windward; then, before the lee-tide is done, put the helm to starboard, to give the ship a sheer, which will be preserved by the position of the sails. At slack water shift the helm: thus, when the tide makes, it will act against the larboard-side of the rudder and stern, and very much assist to swing the ship the right way. Again, should the wind be a-stern, and a little upon the wrong quarter, if the helm be attended to, and the mizen-topfail braced full the right way, in all probability the ship will swing as wanted.

If the helm were only properly attended, it would often save the labour of clearing the hawse.

It would be highly necessary, at all times, to have a small anchor and rope ready abaft, to run out and haul the ship round in calm weather.

EXPLANATION

EXPLANATION OF A FOUL HAWSE.

When a ship is moored, attention must be paid to her swinging at the turn of tide, or shift of wind, to prevent the cables overlaying each other, or getting a foul hawse, which is prejudicial, as the cables chafe each other, and as the vessel is not in that perfect state of security enjoyed by riding with an open hawse. The explanation of this turn will be better comprehended by a reference to the figures.

FIG. 1.

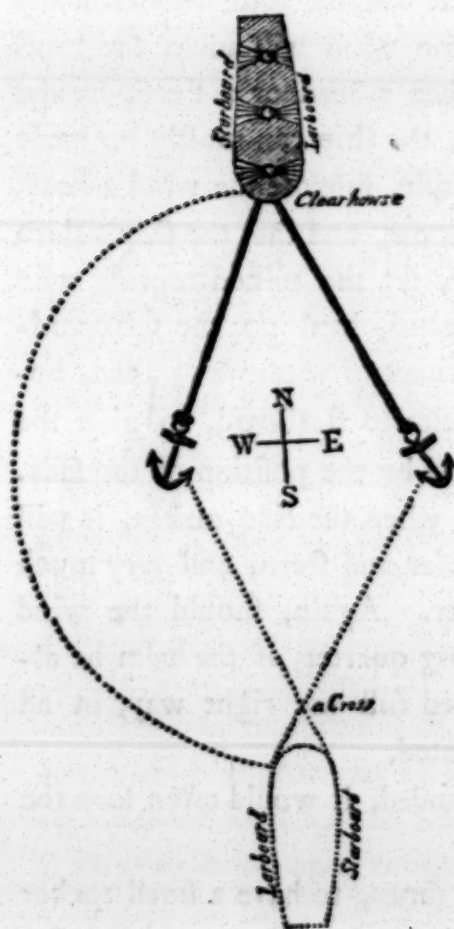


FIG. 2.

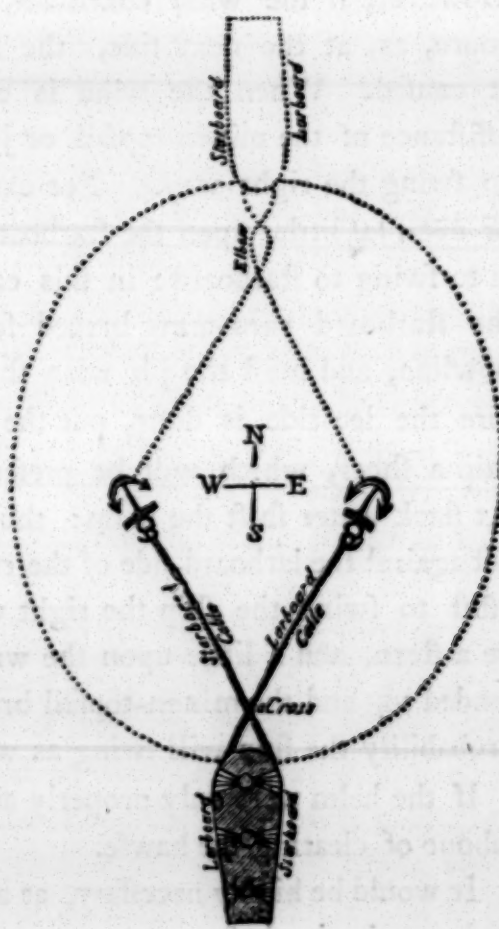
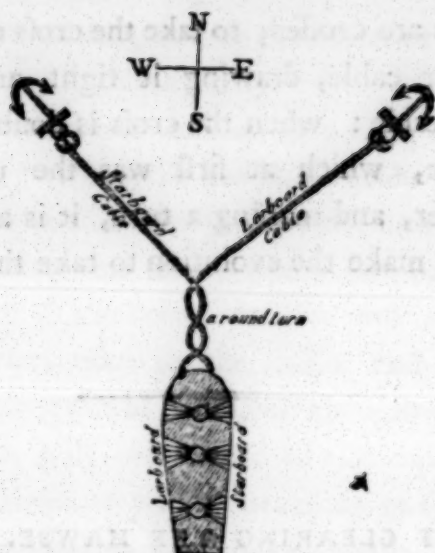


FIG.

FIG. 3.



For example: if a ship be moored east and west, and swings to the northward, the cable of the anchor, lying to the eastward, is from the hawse-hole on the larboard-side, and that to the westward from the hawse-hole on the starboard-side; should the wind or tide change, so as to bring the ship to the southward of her anchors, the western anchor will be on the larboard-side the vessel, and the eastern anchor on the starboard-side. These two cables (the one from out of the larboard hawse-hole, and leading towards the eastward, or starboard of the ship, and that from out of the starboard hawse-hole leading to the westward, or larboard-side of the ship) must consequently cross each other; that by which the rode, when making the movement of swinging, remaining above the other. Suppose, in the present case, the ship has swung by the eastern anchor to the western side, it will then be found in the position shewn in fig. 1.

If, in a second change of situation, the ship is observed to turn round the same anchor, and to the westward, the cross will be taken out, and the cables will resume their first disposition, as in fig. 1.

If, on the contrary, the cross is not taken out, but she swings to the eastward, the cross will be doubled, and form an elbow, fig. 2; and,

and, should she continue to turn westward to the southward, the cables will be again twisted, and form a round turn, as fig. 3, which should be carefully avoided.

When two cables are crossed, to take the cross out, the ship must swing to the upper cable, drawing it tight, and by that means flacking the other cable: when the cross is doubled, and becomes an elbow, the cable, which at first was the uppermost, being overlaid by the other, and making a turn, it is always on the first that the ship should make the evolution to take the turn out.

OF CLEARING THE HAWSE.

This can only be attempted when the ship does not ride by the clearing-cable. To execute it, bend a fish-hook to the fore-bowline, hook this to the cable the ship is riding by, below the turns in the hawse, and bowse it well up out of the water: then lash the cables together at the turns. If the cable, by which the hawse is cleared, leads on the starboard-side, send the larboard fore-top bowline into the hawse-hole under the cable, or under and over, according as the cable to be cleared is either below or above the other, which must be bent about three fathoms within the hawse. Then send in the starboard-bowline, which should be bent well in towards the end of the cable, and stopped along the cable at every fathom, and let a hawse-rope be bent to the end of the cable. When all the bowlines are fast, unbit the cable, and haul out upon the starboard-bowline: let the stops be cut, as the cable comes out of the hawse. When a long bight is out, haul upon the larboard bowline, and trice this bight up to the bowsprit. Should this one bight not sufficiently expend the cable, that its end may be taken round the other, hang it to the bowsprit, and send down the larboard-bowline for a second bight. When the end of the cable is round the other, shift the hawse-rope, and haul it in again. The hawse being clear, bit the cable and unlash it.

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Should it blow fresh, and the tide run to windward, it will be imprudent to trust only to the lashings, lest the cable should run out end for end. In this case, bend the hawser, with a rolling hitch, to the clearing-cable, below the turns of the hawse, and let it be hove tight, as a double security.

If it is moderate weather and an easy tide, the hawse may be readily cleared, by bowfing the headmost cable well up out of the water, and bending to it a hawser from the hawse below the turns. Then unbit the cable, veer away upon the hawser, and pass the headmost cable round the other until its end is clear; then heave in upon the hawser, take in the cable, and bit it. Should it come on to blow a gale of wind, when a ship is moored, from that quarter which will oblige her to ride equally by each cable, and the hawse is clear, it will be necessary to splice a second cable to the small bower, and to veer away equally upon both cables: but, should the hawse be foul, and it is expected that the cables will damage each other, bend a hawser below the turns in the hawse to the small bower, which slip, and let the ship swing to the best bower. When the weather moderates, heave in the end of the small bower, and the ship will be moored as before with a clear hawse.

OF GETTING UP OR WEIGHING ANCHOR.

Previously to entering upon directions for UNMOORING and GETTING UNDER SAIL, it is necessary to shew the various modes of GETTING UP AN ANCHOR, as this operation is often requisite where it is not designed to unmoor, and as it is necessary to know how to overcome the difficulties of getting up an anchor in all cases whatever.

TO GET UP AN ANCHOR, IN SHIPS WHICH HAVE A MAIN AND JEER CAPSTERN.

In large ships which have a main and jeer capstern, and the strain is thought too great for the messenger alone, the viol is used thus: Three or four turns are taken round the jeer-capstern with one end, so as to leave that side clear on which the cable is coming in; and pass the other end through the viol-block, which is lashed round the main-mast on the lower deck. It is then carried forward, and passed round the rollers in the manger near the hawse-holes; then brought aft, and spliced to the other end with a short splice, and the ends marled down tight. That side of the viol on which

which the cable is coming in is fastened to the cable by nippers ; and thus the continued efforts of the capstern are conveyed to the cable, until it is hove in. The nippers are clapt on in the manger, from one to two fathoms asunder ; and the viol is applied to the midships, or inside of the cable. Nippers are clapt on by taking three or four turns round the viol, four turns round the cable and viol, and then three or four turns round the cable. This method is an exceeding good one, and very suitable to quick heaving ; but, when the strain is great, and the cable muddy, the nippers clapt on after this method will not nip sufficiently ; and sometimes recourse is had to the following method : Throw sand or ashes upon the cable, and take a long dry nipper ; which middle, and pass one-half aft, racking it in and out round the cable and viol ; then worm its end round the viol only. After this, pass the other half in the same manner forward, but worm its end round the cable only, and let each end of the nipper be held on. The advantages of this method are, that, as the strain of the cable lies forward and that of the viol aft, the nipper will be drawn so tight as effectually to hold the cable till something gives way : also they can never jamb, for both ends are clear for taking off. Another method, when the strain is great, is, to have nippers with an overhand-knot made at one end ; and with that end a round turn taken round the cable and viol, leaving three or four feet of the end ; then, with the other end, take three or four racking turns, and expend nearly the remainder with turns round the cable and viol, laying the knotted end under and over each of the last turns : the end is then held fast. The men who clap on the nippers are attended by boys, who hold the ends of them ; and follow the progression of the cable as it is hove in : and, as the nippers arrive near the main-hatchway, they are taken off and carried forward, where they are again clapt on : and so in succession, until the cable is hove in sufficiently to raise the anchor above the water. It is then stoppered round all before the bits : that is, round the cable and viol. The anchor is then catted, and afterwards fished. To shift the viol for heaving in a second anchor, it must be unspliced, and the turns round the capstern reversed. When the strain is so great as to require other purchases, the top tackles may be used

thus: The double block is lashed to the main-mast or topfail-sheet bits, the treble block is lashed on the cable, and the fall brought to the capstern. If the top-tackle falls are thought insufficient, any hawser may be used that will reeve through the blocks.

TO GET UP AN ANCHOR IN SHIPS WHICH HAVE NOT A
JEER-CAPSTERN.

Ships without a jeer-capstern have no viol, but heave in their cables by the messenger, which has an eye spliced in each end; one of which ends is passed with three or four turns round the capstern on the upper deck, and the other end passed forwards round the rollers, at the fore-part of the manger; then brought aft to the other end, and lashed thus: Several turns are passed through the eyes crossing each other in the middle, then a half-hitch is taken round the parts, and the end stopped with spunyarn. The remainder of the operation is performed as by the viol, with this exception; the messenger is applied to the outside of the cable; and, when the nippers are insufficient, the messenger may be hitched thus: The bight of the messenger is fastened round the cable at the manger with a rolling hitch, and the bight seized round the cable before the hitch. This practice is by no means so good as the others.

When getting under way in a sea-gale, the viol is better than a messenger, as the sending of the ship carries all the strain to the main-capstern, and endangers the men at the bars; whereas, with a viol, the strain is taken to the viol-block, and the men at the fore-jeer capstern heave in security.

TO GET UP A SECOND ANCHOR.

Suppose, by the former methods, that the starboard-anchor is gotten up, and that the cable of the second anchor enters the larboard hawse-hole, the operation of getting up the second anchor is the same, observing only, that the messenger must be shifted, and the turns on the capstern reversed, to change the disposition and side: and the men, who before held on the larboard-side in the first operation, will hold on the starboard-side now: the motion of the capstern is performed the contrary way, and the cable on the larboard-side is fixed and hove in.

TO GET UP AN ANCHOR IN MERCHANT-SHIPS.

Most merchant-ships and small vessels heave up their anchors by a windlafs; round which are taken three turns of the cable, and held on by hand, or by a jigger, thus: The end of the rope which has the sheave is passed round the cable, with a round turn, close to the windlafs, the leading part of the rope coming over the sheave, and stretched aft, by means of the fall passing through the jigger-block; the standing part of the fall is made fast round a stantion, at the fore-part of the quarter-deck, and the leading part is bowled upon, which jams the turns taken round the cable; and, when the jigger arrives abreast of the hatchway, it is removed forward, and the cable is jammed by a handspeck at the windlafs, until the jigger is refixed.

TO WEIGH AN ANCHOR WITH THE LONG-BOAT.

This is done, by taking the long-boat to the buoy of the anchor, and putting the buoy-rope over the davit of the long-boat, and a tackle on the buoy-rope; by which, with the assistance of men on the fall, the anchor is weighed out of the ground. This being accomplished, the cable is hove in on board; the buoy rope and tackle being secured in the boat, they approach the ship as the cable is hove in, and the anchor catted and stowed. Small anchors and grapnels are got up by the davit, hauling upon the cable or grapnel-rope by hand.

TO WEIGH AN ANCHOR BY UNDER-RUNNING.

This is by placing the cable over the davit-head, and under-running it, till it is nearly a-peek, when it is tripped by means of tackles as before by the buoy-rope. This method is troublesome, and is only adopted when the buoy is gone, and a ship cannot get near her anchor for want of water.

OF CUTTING OR SLIPPING THE CABLE TO MAKE SAIL.

This is a quick but very expensive method, and practised but in cases of the greatest necessity; such as when the anchor is hooked to rocks, and cannot be purchased; in bad weather; when at anchor on a lee-shore and in danger of being embayed; or when compelled

compelled to fly from or pursue an enemy. The cable is cut by an axe at the hawse-holes or at the bits. Slipping the cable, if time will permit, (which prevents losing the anchor and cable, and is more prudent than cutting,) is by letting the cable run out end for end. Observing however before it is either cut or slipped to pass a spare buoy-rope in the hawse-hole, and fasten it near the end with a rolling hitch; worm the end in the cuntline and stop it, that it may be easily regained.

TO SWEEP AN ANCHOR.

To sweep an anchor is seeking at the bottom for one lost, by means of a rope called a sweep. This rope has its two ends made fast to two boats abreast of each other, at a small distance asunder. On the bight of the sweep is fixed a weight of shot, ballast, &c. to keep it at the bottom. The two boats row on toward the place where the anchor is supposed to be, and consequently draw along the sweep; which, taking the bottom, hooks or entangles itself with the object of their search. The boats then row across each other twice, so as to take a round turn with the sweep, which being a hawser, both parts are brought into the hawse-hole and to the capstern, (or if small to the long-boat,) and hove in upon as before.

TO UNMOOR.

Should the ship to be unmoored have her best bower to the ebb, let her be unmoored upon the ebb-tide : but, if there were a necessity to unmoor upon the flood, the stream-cable must be spliced to the small bower, supposing the small bower has but one cable. To unmoor upon the ebb, when it has made strong, veer away the best bower, bring-to and heave in the small bower, and keep veering away the best, till the small bower is up-and-down ; then stopper the best bower.

The small bower being up, cat the anchor, shift the messenger, bring-to the best bower, and heave in to the whole or half-cable service, as may be thought necessary ; then bit the cable, and fish the small bower anchor.

Should a ship be under the necessity of unmooring upon a windward-tide with a strong wind, it will be very difficult and dangerous to take up the sternmost anchor. In this case, if there be no ships in the way, the headmost anchor may be the first taken up with safety, and the sternmost cable be hove in towards slack water.

OF GETTING UNDER SAIL.

GENERAL OBSERVATIONS RELATIVE TO GETTING UNDER SAIL.

Whenever a ship is preparing to get under sail, the topfail-yards ought to be at the mast-head, and her sails stopped with rope-yarns. And indeed all persons that pique themselves on rapid execution ought to observe this precaution when the wind is not too powerful.

When the tide takes a ship on the beam, and she is to cast the other way, it is evident that the tiller in the first instant must be put on the side the current runs from, because the rudder will be in such a situation as to receive very obliquely the impulse of the fluid, and consequently will but little oppose the ship's falling off, provided the ship's velocity does not exceed that of the current.

When in a situation where it is indifferent whether the ship be cast one way or the other, always let it be to leeward of the anchor, that there may be no risk of its getting foul of the cutwater.

It happens sometimes, in getting under sail, that you are obliged to heave the anchor up to leeward; which often requires a dangerous strain to the capstern; because the ship, driving to leeward as soon as the anchor is a-weigh, causes the cable to girt against the lee-bow, and the stock of the anchor is very apt to catch the

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cutwater.

cutwater. To avoid this, let the ship, (if you are near the land,) get offing enough to wear and bring the anchor on the weather-bow: then the ship, lying to leeward of the anchor, or standing-on under an easy sail, drifts, and consequently leaves the anchor disengaged to windward; in which situation it may be hove with facility.

TO GET UNDER SAIL WHEN THE SHIP IS SWINGING HEAD TO WIND, AND YOU WANT TO CAST EITHER TO STARBOARD OR LARBOARD, IN A PLACE WHERE THERE IS NO CURRENT.

TO CAST TO STARBOARD.

Heave short on your anchor till it is a-peek: then haul in quite home the larboard-braces forward and starboard-braces abaft: loosen, sheet-home, and hoist, the topails, should they not be so already: put the helm a-starboard, and heave till the anchor is a-weigh. The moment the anchor quits the ground, the ship will begin to fall off to starboard. As soon as this movement is perceived, hoist the jib and fore-topmast stay-sail, if necessary, to help her: and, when she has sufficiently fallen off, her sails abaft (which are trimmed sharp for the larboard-tack) will fill. But, unless for very superior reasons, you had better continue lying-to till the anchor is catted, taking care to haul the mizen-sheets close aft, if the ship be inclined to fall off too much.

TO CAST TO LARBOARD.

Haul in the starboard-braces forward and the larboard aft, and put the helm a-port. The rest of the operation is the same as the preceding; and will be equally proved in the following demonstration, by only changing starboard for port.

DEMON-

DEMONSTRATION.

You heave short before the top-sails are loosened, in order to facilitate the working of the capstern, which would require dangerous efforts if they were set; since they would be a-back, and consequently in a situation to send the ship a-stern; whereas she should go a-head when you are heaving on your cable. The larboard-braces are hauled in forwards, because, in that situation, the sails are so braced as to cast the ship's head to starboard, since they make with the keel the most acute angle possible a-starboard forward, and are at the same time a-back. Besides, the after-sails, being braced sharp up to starboard, are also taken a-back like the others, and receive the wind in such a manner as to turn the after-part to port. So that there are always two powers acting in contrary directions, one before and the other abaft the centre of gravity of the ship; the one forcing the fore-part to starboard, and the other impelling the after-part to larboard. As these two effects cannot happen without the ship's going a-stern the moment the anchor quits the ground, since she is no longer with-held by any thing, and is moved by an exterior power, the fluid, which carries her in this direction, part of the effect of her sails giving her stern-way; (§. 21;) it follows, that the helm must be put to starboard, that the rudder may help her after-part round to larboard. (§. 58.) Thus every thing is disposed to make the ship fall off to starboard. The jib and foretopmast stay-sail are not added, unless there be reasons to fear the ship will not fall off fast enough; and, when you find she has sufficiently done so, the mizen is to be hauled out, to procure the contrary effect, and thereby to counter-balance the jib and stay-sail, which it is very often necessary to keep set.

TO GET UNDER SAIL, WHEN THE SHIP IS RIDING HEAD
TO WIND AND TIDE.

If a ship, riding head to wind and tide, wanted to get under sail, after having decided on which side it is best to have her cast, it must be performed according to one of the foregoing methods, except with regard to the helm, which must be put to starboard, either before the anchor loosens, or while it does, if you wish to cast to port; because the water, coming from forward, acts with the same force on the rudder as if the ship went with the current, impelling the rudder to starboard and the head to port. Therefore it is evident, in this case, the helm ought to be put to starboard; which, on the contrary, would be put to larboard, was the ship to be cast to port.

If the ship, after the anchor is out of the ground, goes a-stern faster than the current runs, the helm must then be used as if there was no current, because the excess of velocity, whereby the ship exceeds that of the water, acts upon the rudder,

If it blows fresh, so that you cannot set your topfails without reefing them, let that be done before they are sheeted home; and if it blew so hard as to be obliged to go only under a fore-sail, it would be then sufficient to loosen the fore-topfail; without sheeting it home, after having braced it quite close on the side opposite to that you want the ship to cast, not forgetting however to put the helm the same way as you cast, as soon as you perceive the ship going a-stern: and when the ship has fallen off sufficiently, then is the time to fill and trim the fore-sail.

TO GET UNDER SAIL WHEN THE SHIP IS SWINGING WITH HER HEAD TO THE CURRENT, AND WITH THE WIND A POINT ABAFT THE BEAM.

The topfails being stopped with rope-yarns, let them and the mizen-topfail be hoisted, and properly trimmed, as if they were set; and, when every thing is properly disposed, heave short on your anchor till it is a-peek; next to this, loosen, sheet home the fore-fail and mizen-topfail, keeping the wind in, and heave vigorously at the capstern till the anchor is a-weigh. At the same time hoist the jib and fore-topmast stay-fail, or haul out the mizen, according as circumstances may require. Whether you wish to come to windward, or fall off more quickly, you must still continue to heave round the capstern briskly to get the anchor up, till you find yourself sufficiently offward to bring to, in order to stow it with ease, or to stand on under an easy fail with the anchor hanging out to windward, if the situation of things will admit of it. You may sometimes also hoist up both the main and fore topfails, as soon as you get ready; but, in certain cases, as when obliged to make the best of your way from an enemy, every fail possible must be set at once which the weather will admit of; especially when obliged to haul by the wind; in which case, the anchor must be got up and catted as well as it can: there are cases even when, without losing your time in weighing it, you crowd as many fails as you possibly can, and depart in cutting or slipping the cable.

DEMONSTRATION.

The topfails and mizen-topfail are hoisted up, because the fails in that situation are more easily sheeted home and trimmed; and because, as soon as the rope-yarns are cut, the fails fill, and give the ship head-way, the moment the anchor quits the ground. The
mizen-

mizen-topfail is used to make the ship steer well, by keeping it either filled or loose to the wind, according as the ship is griping or the contrary.

TO GET UNDER SAIL WITH A SPRING.

If a ship be in a place too confined to cast under her sails only, or being obliged to put to sea in a gale of wind, without hoisting the anchors; you must, for greater safety, in casting the right way, get a spring out, to be clapped on the cable by which the ship swings, by passing a hawser or a stream-cable through the aftermost port, on the opposite side to that you mean to cast; and, after that spring is well hove tight at the capstern, hoist the jib and fore-topmast stay-sails, loose and sheet home the fore-topfail; when that is done, and if the weather permits, brace quite close the head-sails on the same side with the spring. When this is executed, slip or cut the cable, heaving briskly at the same time on the spring, till the ship has paid off sufficiently. Then fill the sails, by setting the mizen-topfail and every other sail you mean to employ, and slip or cut the spring, as circumstances may require. Care must be taken, not to let the ship fall off too much before the spring is cut; because, having no way through the water, she will not come to the wind so soon as might be wished; and, for the same reason, the spring must not be cut, till she has fallen off as much as is necessary; because, although she has no other motion but that of falling off, the vessel might perhaps not wear enough to answer the purpose,

DEMONSTRATION.

As the reasons have been shewn before why the head-sails are braced up on the opposite side to that on which the ship casts, they need

need not be repeated here. Although we suppose the wind so strong as to keep the ship wind-road, it may be proved that the ship turns almost on the middle of her length; since the moment the fore-part begins its movement of falling off on one side, the after-part makes another to approach the point from which the head is receding. Now she turns so much the more surely on her centre, and her evolution is so much the more rapid, as the force used in heaving at the capstern is stronger: because the more powerful the heaving is, the more of the hawser comes in, and consequently the more easily and with the greatest rapidity will the after-part approach the point the head of the ship has left.

When she has fallen off enough, slip the spring, because she gathers head-way in proportion as the sails are filling, and in that case the hawser would only hinder the ship going a-head, or cause her to fall off more, which would be equally prejudicial. The hawser or stream-cable is passed aft as far as possible; because, being at the extremity of the ship, the capstern strains less, and the vessel turns with more celerity.

If this operation is performed when it blows hard, you must not sheet home the fore-topfail: for, if the wind is absolutely too strong, you must only loosen this fail, and hoist the fore-topmast stayfail: but, if the weather is pretty tolerable, it will be found sufficient to sheet home the fore-topfail without hoisting it.

TO GET UNDER SAIL WITH A LEADING WIND IN A TIDE-WAY.

If the ship to be got under sail has a leading wind, and is in the midst of vessels, or in a narrow channel, where it would be difficult to cast her upon the lee-tide, she should be got under sail before the weather-tide is done. Thus the casting of the ship would be avoided, and she may be steered through the fleet or channel with safety.

Should

Should it, however, blow so fresh upon the windward-tide, as to force the ship end-on with her cable, it will be impossible to heave it in, without sheering the ship over from side to side, and heaving in briskly, as the ship flacks the cable; but, as this is attended with much danger, by the ship suddenly bringing up upon each sheer, it will be best to heave a-peek upon the first setting of the windward-tide, before the ship swings, to bring the wind aft.

TO CAST A SHIP UPON THE LARBOARD TACK, AND BACK
HER A-STERN OF DANGER.

We suppose the ship to lie at single anchor, with the wind and tide the same way, and ships or shoals right a-stern, in the intended course, and that, to clear them, you must cast upon the larboard-tack, and make a stern-board.

Make every thing as ready as possible before weighing: let the three topfails be hoisted, the yards braced up sharp with the larboard-braces, and the mizen hauled out. Thus situated, when the anchor weighs, put the helm a-port. The tide, running aft, acts against the starboard-side of the rudder; and, in that direction, it will cast the ship the right way, and bring the wind upon the larboard-bow. The wind may be thus kept, at pleasure, by the helm, till the ship begins to get sternway through the water, which should be attentively noticed, to put the helm hard a-port. The wind, being on the larboard-bow and the topfails a-back, will soon give the ship sternway through the water; then the water will act against the larboard-side of the rudder, and powerfully prevent the ship falling too fast off from the wind. Thus she will drive till the anchor is got quite up, and may be so continued till she has past the shoals, and has room to veer, and get upon her proper course.

It

It is advantageous to make a stern-board in getting under way from a single anchor in the above situation. The anchor heaves up more easily when the ship goes a-stern; and, while heaving up, it serves to keep the ship's head to the wind. A ship, however, cannot long be steered stern foremost when under sail, so as to keep the wind before the beam; but she will in a little time drive broadside through the water, till she gets headway, and then it is proper to veer, provided the anchor be quite up.

TO CAST A SHIP ON THE LARBOARD TACK, IN A TIDE-WAY, WITH THE WIND TWO POINTS ON THE STARBOARD-BOW.

A ship riding in a tide-way, with the wind two points on the starboard-bow, and so near the shore, on the larboard-side, that she must be cast upon the larboard-tack to clear the shore, the *three* topfails must be hoisted, and the yards sharp braced up, with the larboard-braces forward, and the starboard-braces aft, with the starboard fore-top bowline well hauled, putting the helm hard to port at the anchor's weighing: the tide acting upon the rudder, and the wind upon the sails *braced in that direction*, brings the ship about, with the wind on the larboard-bow, before she gets sternway, which should be always strictly noticed; for, in all proceedings of this kind, if a ship gets sternway before she brings the wind right a-head, she will not come about the right way. In that case, it is best to veer away the cable directly, and bring the ship up again: and carry out a kedge or small anchor on the larboard-bow, hauling its *cable* or hawser in tight, on the larboard-quarter, when the bower-anchor is a-peek. If this fail, the ship must lie till the windward-tide makes, to bring the wind on the larboard-bow, when the ship may be got under-way, and clear the shore.

TO CAST A SHIP UPON THE LARBOARD TACK, AND SHOOT
HER BY THE WIND A-HEAD OF DANGER.

If there is but just room enough close by the wind to clear a danger lying to leeward, much depends on heaving up briskly the anchor after it is out of the ground, and having proper sails ready to set to the best advantage. The three topsails must be hoisted, and the yard sharp braced up with the larboard-braces forward, and the starboard-braces aft, when the anchor is at a long peek. At weighing the anchor, put the helm hard to port, then the action of the tide upon the rudder, and the wind on the fore-topfail, will cast the ship off the right way, so as to fill the after-sails, when the fore-topfail may be soon braced about and filled before she gets sternway. The helm will keep the ship under command sufficiently to steer her by the wind a-head clear of danger; but, if the ship gets sternway in casting, the helm should be kept hard a-weather to prevent her falling off too much from the wind; and, when she gets headway again, be cautious how the weather-helm is eased with the anchor much below the bows, by which the resistance forward is increased, and the ship may be brought up in the wind, so as to prevent her shooting clear of the danger. This must be guarded against by the weather-helm, and head-sails, as jib, fore-topmast, stayfail, &c. As soon as the ship has shot far enough a-head to clear the danger to leeward, and there be but little room a-head, it is best to bring the ship to and drive with the helm a-lee, with the main and mizen topfail a-back, and the fore-topfail shivering till the anchor is up: then take proper time to veer.

TO CAST ON THE LARBOARD TACK, WHEN RIDING WITH THE WIND RIGHT A-HEAD, AND TO VEER HER SHORT ROUND BEFORE THE WIND IN LITTLE ROOM.

The head-fails should only be loose, viz. the fore-topfail hoisted and the fore-fail loose: brace sharp up with the larboard-braces, the jib and fore-topmast stayfail set, with the larboard-sheets flat aft. When the anchor is a-peek, and a lee-tide running, at weighing the anchor, the helm should be put to port so far as to bring the wind two points on the larboard-bow, which should be kept so by steering the ship till the tide ceases to run aft. Then put the helm hard to starboard, or a-lee; and, when the ship gets sternway, the water will act powerfully on the starboard, or lee, side of the rudder, turning the ship's stern to windward, whilst the wind, acting at the same time upon the head-fails a-back, will box her round off upon her heel, so as to bring the wind nearly aft by the time she loses her sternway. Then the ship will cease falling off and soon get head-way, which should be attended to, and the head-fails braced about flat with the starboard-braces, and the helm shifted hard to port at the same time.

When there is no tide, but still water, at weighing the anchor, the helm must be hard to starboard; and, as the ship gets sternway, the water meets with so much resistance against the starboard-side of the rudder in that direction, that the rudder acts with great power to turn the ship's stern round to port, and the head-fails being set and trimmed as before-mentioned, and the foresail let fall with the starboard-bowline hauled close forward, will assist to cast the ship so far round the right way, by the same time she loses her sternway, as then to permit your proceeding as before-directed. To ensure success, heave the anchor up briskly. The same methods are adopted in casting the ship on the starboard-tack, only the helm and sails are managed the contrary way.

ON TACKING.

TO TACK A SHIP IN GETTING TO WINDWARD AS MUCH AS POSSIBLE.

To execute this with propriety, care must be taken that the ship does not yaw, that she is not too near or too far from the wind; because both situations are equally prejudicial.

When this medium is obtained, haul the mizen out, while you put at the same time the helm a-lee, and brace the bowline quite to leeward, that the mizen may be as much as possible exposed to the wind. When the ship is come to the wind, so as to cause the square-sails to shiver, let go the jib and all the stayfail-sheets before the main-mast: at the moment when all the sails catch a-back, and particularly the mizen-topfail, let it be braced sharp about the other way; hauling up at the same time the weather-clue of the main-sail; and, when the wind is right a-head, or even a little before, haul the main-sail, and trim sharp for the other tack as fast as possible. The jib and stayfail sheets are also to be shifted over at the same time, in righting the helm, whether the ship has lost her way, or even still advances a-head. Then, as soon as she has passed the direction of the wind about 45° , in continuing her evolution, shift the foremast's sails, which are to be trimmed with the same celerity as in putting the helm a-lee, if you fear the ship (which must still go a-stern if the operation be slowly executed) will

will not fall off sufficiently: for, if the sails are braced about briskly, she will never have sternway; on the contrary, she will get a great deal to windward.

DEMONSTRATION.

If the ship be too near the wind, when the helm is put a-lee, she will most probably miss stays; since, not having sufficient way through the water, the rudder will not have a sufficient power to cause the ship to double the critical point where all the sails shiver. The power of the rudder to turn the ship is in proportion to the force with which the water strikes it. (§. 58.) Hence it follows, that, if the ship has not sufficient velocity, the rudder will not have force enough to cause her to double the point, where all that can augment or keep up the rapidity of failing (and of consequence the power of the helm) will cease, the sails being all shivering. The ship must then necessarily fall off, since the helm is a-lee, and none of her sails tend to shoot her a-head. On the contrary, her mizen being out, and braced quite to leeward, forces the stern of the ship athwart; (§. 40;) while, by the wind which strikes her sails, rigging, and hull, she is but too ready to drive a-stern, as a ship always finds great difficulty to divide the fluid laterally. Thus it is clear, that, every thing being disposed for driving the ship the sternway, she must infallibly both go a-stern and to leeward. (§. 58.) This is confirmed by experience; for, whenever a ship misses stays, she is visibly perceived to fall abaft.

If, previous to tacking, a ship is kept too much away, she will be longer in ranging to the wind; which must consequently be disadvantageous to the evolution. We should not have mentioned this custom, did not many seamen, through mere habit, put it in practice, and thereby fail in this operation, which would however have succeeded, had they not had the habit of letting go the fore, jib, and stay-sail, sheets. When these have been kept fast, the edging away can only prolong the time of the evolution; but, if the fore, jib, and stay-sail, sheets be let go, as a great many do at every turn, and as in some particular cases it is really found necessary,
care

care must be taken not to suffer the ship to fall off too much : because the velocity of the ship not being sufficiently kept up (§. 46) till the ship comes to the wind, it follows that she has lost a good deal of it, before she arrives at the critical part of the evolution, where all the sails shake. So that, when the ship is at that point, the velocity is so much diminished, the rudder has not power enough to make her double it : on the other hand, the fore-part of the ship is no longer carried to the wind with the same force, since the vessel no longer shocks the fluid (§. 47) with her first velocity.

The mizen is hauled out to help the rudder ; because these two forces act together in impelling the after-part of the ship to leeward. (§. 40 and 50.) When the helm is a-lee, the ship of course comes head to wind ; and continues that circular motion, first by the effect of the rudder, till the head-way ceases, and then by that of the mizen, till the other sails take the wind from it. Therefore, when the mizen is becalmed by the other sails, the evolution is sure, as this could not happen if those sails were not taken a-back.

You must wait till the square-sails begin to shiver, before letting go the jib and all the stayfail-sheets before the main-mast ; because, till that moment, these sails concur to maintain an equilibrium with the others, and keep up the ship's velocity ; since it is the disposition of the different sails set on the different parts of the ship, which gives her more or less way through the water. (§. 46.) These however being now the only sails which tend to make the ship fall off, (§. 31,) since they are the only sails full, the others being shivering, it is absolutely necessary at this moment to suppress that effect, since it is contrary to the movement of coming-to ; the action of the mizen is, however, to be preserved as long as possible, in order to help the rudder, which, in keeping up the movement of rotation of the ship, will soon make her clear the critical point of the evolution.

Experience teaches that the motion of the ship, in coming to the wind, at the moment the jib and stayfail sheets are let go, is very rapid, provided the other sails shiver ; because the velocity of the ship, at that motion, is as great as when all the sails were exposed

posed to the impulsion of the wind. Consequently, the effort of the rudder is likewise very powerful, (§. 50,) since the rapidity of sailing has not diminished.

The mizen sail is to be braced up so far as to join the main-shrouds to windward; because in that situation it is exposed as much as it possibly can to the wind, and receives consequently a stronger and longer impulsion; and, again, because it is trimmed as it will remain even after the evolution has been performed.

The mizen-topfail should be braced about as soon as it is taken a-back, because it will then impel the stern to leeward, jointly with the mizen, (§. 44,) and, by this new disposition, accelerate the evolution: whereas, if it were continued in its first situation, it would retard the circular motion of the ship, by impelling the after-part to windward. (§. 45.) It will also, in this situation become very useful, in moderating the stern and lee way of the ship.

At this same time, the weather clue and sheets of the main-sail are hauled up, in order that all may be ready to brace round for the other tack.

The main-fails are to be hauled about and filled when the wind is right a-head; because, 1st, at this time the fails on that mast are becalmed by those of the fore-mast: 2^{ly}, should they be left longer in this situation, they would counteract the head-fails, (§. 37, 38, 44, and 45,) which are braced up for the same tack, and in the same manner; and, finally, because, were it not for this, the sine of incidence of the wind on them would be continually increasing as the ship were falling off, which would more and more retard her bearing away.

It is, notwithstanding, not untrue, that the evolution would be more rapid, if the fails on the main-mast were filled as soon as they are taken a-back: because (§. 44) they would impel the after-part of the ship to leeward. But this effect of the after-fails ought not to be attended to, except when the ship has lost her velocity, and the rudder its power. Whence it must be concluded, that the ship will always fall off with great celerity as soon as the main-sail is hauled.

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The jib and stay-sail sheets are also shifted at this time, if they have not been lowered before; because, if sooner, they would take the wind in again, which must not be done before the ship has fallen off sufficiently to clear the direction of the wind.

The helm is to be righted if the ship has lost her way; because, if it were continued a-lee, as in the first instant, and the ship should get sternway, the rudder (§. 58) would oppose the evolution, which must now be finished with sufficient rapidity by the sole effect of the head-sails, as these are now fully exposed to the power of the wind. Great care must be taken not to slack the bow-lines, as is often done by people who act more from custom than reflection.

The head-sails are to be braced about and filled, when the ship has got over the direction of the wind by 45° , or thereabouts; because, if they were left longer a-back, the motion of the ship's falling-off would become too rapid and too great. If they are braced about briskly at the time before-mentioned, they may be made to shiver; which, by diminishing their effect, will moderate the great velocity of falling off which the ship has acquired. (§. 37.)

The helm ought to be put a-lee (§. 58) if the ship goes a-stern, to aid her falling off, which is now carried on only by the jib and stay-sails before the centre of gravity. Thus the ship falls off moderately, in yielding to the wind by 12° or 20° only, more large than if close-hauled; because the after-sails, being trimmed sharp, soon bring the ship to the wind, and give her head-way. (§. 41.) Let it not be forgotten, that the helm ought not to be put a-lee in hauling off all, unless you judge the ship not sufficiently inclined to fall off, which however seldom happens when she is come to this point.

THE DEMONSTRATION OF THIS EVOLUTION COMPREHENDS THE WHOLE PLAY OF THE SAILS AND OF THE RUDDER; SO THAT ALL OTHER DEMONSTRATIONS MIGHT BE CONSIDERED AS SO MANY COROLLARIES DEDUCED FROM IT.

**TO TACK A SHIP, WITHOUT ENDEAVOURING TO GET TO
WINDWARD.**

There are circumstances sometimes when it is found necessary to tack, without caring much whether the ship loses to windward. For example: When a ship is found suddenly to be close to the land, in the night, or in foggy weather, near a danger, or some vessel, which must instantly be avoided by staying the ship, because you find yourself to windward, and too near the object from which you wish to recede: in this case, when it is necessary to deaden the ship's way, and tack at the same time, you must suddenly put the helm hard a-lee; and, in the same instant, let go the jib, fore, and stay-fail, sheets, without touching the bowlines; and great care must be taken that the effect of the mizen is preserved as much as possible. When the sails begin to shiver, the mizen is to be hauled quite in the lee-braces; then, if the ship takes well the wind a-head, the remainder of the operation must be executed as directed in the preceding case; but, if you should miss stays, you must proceed according to the second method of veering, called BOXHAULING.

DEMONSTRATION.

It is easily conceived, that, in letting go the fore, the jib, and stay-fail, sheets, the ship's head-way will be diminished, (§. 46,) while, at the same time, almost all the forces forward are taken away, which might hinder her coming to the wind (§. 31): therefore the ship must come to it rapidly, by the effect of her after-fails, (§. 41,) which are trimmed sharp, and by the power of the helm, (§. 50,) till all the fails shake. It is also easy to conceive, that, when the mizen is hauled in the lee-braces, it has a greater power to impel the after-part of the ship to leeward, and the fails

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consequently to take a-back. So that the ship's head-way will the sooner be stopped; and, the fore-sheet being gone, the sail to windward makes a large cavity between the masts and shrouds, which very much contributes to send the ship a-stern. Attention ought therefore to be paid to catch the instant, when the head-way ceases, to shift the helm and aid the ship in her evolution; as we hinted already. The reason this method is not always practised is, because the ship would lose a deal of ground in driving to leeward. It ought, therefore, never to be used but when necessity obliges, and the vessel has good way through the water; for, if she has not, she will generally miss stays.

TO TACK A SHIP IN A DANGEROUS ROUGH SEA, WHEN
HER STAYING IS DOUBTFUL.

Let every thing be got clear and ready; the hands at their proper stations, the sails trimmed fair, and the ship steered just full, and close by the wind. Take the advantage of the smoothest time when the ship has the most head-way. The other necessary precautions are, to haul down the jib, if set, and not to put the helm a-lee all at once, but to luff the ship up by degrees, to shake the sails. When they shake, give these orders:— The helm hard a-lee; let go the lee-sheets forward, but not the lee-braces and fore-top bowline, as that usual practice backs the head-sails too soon, and stops the ship's headway, which ought to continue to give power to the helm till the wind is brought a-head, or the ship will not stay. Raise tacks and sheets and main-sail haul, when the wind is a-point on the weather-bow; this swings the yards round sharp, that the main tack may be got close down, whilst the head-sails becalm the fore-leech of the main and main-top sails; while the wind, blowing asslant on the after-leech of these sails, acts jointly with the rudder to turn the ship's stern, so as to bring her about

about the right way. When she has fallen off five or six points, let go and haul.

When a ship comes about, she is sure to have sternway by the time the head-sails are hauled; therefore, the helm should not then be shifted a-lee, but should be kept hard a-weather, till her sternway ceases. The water, acting upon the weather-side of the rudder prevents the ship falling round off from the wind, which the helm, when hard a-lee, occasions, while the sternway continues. Notice should be made by the compass, that the ship continues coming about till the wind is on the other bow; for, if she stops with the wind a-head, and her headway is perceived to be done, the helm should be directly shifted to the other side; so that, by the sternway, the water may act upon the rudder and bring her about, and then the helm should not be kept a-lee, but directly shifted and kept hard a-weather till her sternway ceases. For the reason just given, the head-sails may be hauled as soon as possible; for, the ship will be sure to fall off the faster and farther in proportion to her sternway; so that the weather-braces should be tended, to prevent the head-yards flying fore and aft, as they will do when it blows fresh; and to keep the head-sails shivering, that the fore-tack may be got close down easily, and the ship stop the sooner from falling off. Shift the helm a-lee when the sternway ceases, and the head-sails may be trimmed sharp as the ship is perceived to come-to.

ON TURNING TO WINDWARD IN VERY NARROW CHANNELS.

At weighing, if the wind is partly across the tide, it will cast the ship with her head towards the weather-shore, which she may be kept clear of, by driving with the sails a-back till the anchor is up and stowed; and, as the tack towards the weather-shore is the shortest, it is prudent to back as near the lee-side as possible, in order to make the first board the longer; to get the three top-sails,

jib, stay-sail, and mizen, properly set; and to get all ready in time for tacking. Make as bold as possible with the weather-shore, because on that side a ship is always surest in coming about; and, in case of missing stays, a ship may be backed off from the weather-shore, till she has room to fill and set the sails, and get sufficient headway to try her in stays again without danger. But, when the ship is got about, and standing towards the lee-shore, it may be necessary to put her in stays in good time; because she does not so certainly stay when going slanting with the tide as when going across it.

By staying her thus in good time, if she even miss stays, there may be room enough to fill and try her the second time, or to use such means as may prevent her going on shore.

But, when the wind is right against the tide, which begins to make to windward, be cautious not to weigh the anchor till the ship swings end-on to the tide, and brings the wind so far aft, that she may be steered right against the tide till the anchor is up and stowed, and the sails, with which the ship is to work, are all ready.

Haul the wind and get ready for tacking, when you are close over to one side, to gain the whole breadth of the channel for getting underway. For this purpose, let the first trip be made as short as possible, till it is found how the ship works upon both tacks; and then make longer or shorter boards accordingly, but take care not to stand into an eddy tide on either side, which has often occasioned ships to miss stays and go on shore. If a ship will not stay, she must be veered, box-hauled, or club-hauled,

OF VEERING.

TO VEER A SHIP WITHOUT LOSING THE WIND OUT OF HER SAILS.

To execute this evolution both the main-fail and mizen must be hauled up, the helm put a-weather, and the mizen top-fail a shivering, which will be kept so till the wind be right aft, suppressing for that purpose the effect of all the stayfails abaft the centre of gravity. As the ship falls off, (which she will do very rapidly,) round-in the weather-braces of the sails on the fore and main mast, keeping them exactly trimmed to the direction of the wind, and remembering also that the bowlines are not to be started till the ship begins to veer. As she falls off, ease away the fore-sheet, raise the fore-tack, and get aft the weather-sheet, as the lee one is eased off; so that, when the ship is right before the wind, the yards will be exactly square. Then shift over the jib and stayfail sheets; and, the ship continuing her evolution, haul on board the fore and main tacks, and trim all sharp fore and aft, remembering to haul aft the mizen and mizen-stayfail sheets as soon as they will take the right way, or when the ship's stern has a little passed the direction of the wind. When the wind is on the beam, right the helm to moderate the great velocity with which the ship comes-to; the sails being trimmed, stand on by the wind.

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DEMONSTRATION.

The main-fail and mizen are hauled up, and the mizen-topfail shivered, in order to facilitate the evolution (§. 40 and 41). The main-fail, however, might be excepted from this rule, by letting go the main-sheet (§. 49), and working it like the main-topfail. The helm is put a-weather, because, in that situation, the rudder (§. 50) causes the ship to fall off, or yield to the impulse of the wind, by impelling the after-part of the ship to windward with so much the more velocity, as the power of the head-fails exceeds that of those abaft (§. 47); and, as the rapidity of failing increases, the effect of the helm augments in the same proportion. The fails are trimmed to the direction of the wind, as the ship veers, to increase her head-way, and of course the power of the rudder (§. 58); which, in great evolutions, is the chief mover and principal agent of the movement of the ship. So that, its effects being augmented, the ship's circular motion is of course accelerated in the same ratio; and, if the wind be well followed, every fail will be found properly trimmed when the evolution is finished. Since the fails must be kept in a proper situation with respect to the wind, except the mizen topfail, (which, from its situation on the after-extremity of the ship, would retard her veering,) the fore-sheet must be eased off to leeward, and gathered aft to windward, but in proportion as the ship falls off. It is also evident, for the same reason, that the bowlines must not be started till the ship begins to veer. When the ship is right aft, the jib and stayfail sheets, which are then becalmed by the square-fails, are shifted; because, the ship coming to the wind, they are ready trimmed, and highly serviceable in keeping her under command.

The mizen is hauled out as soon as the ship's stern has passed the direction of the wind, to accelerate her coming-to (§. 40); and the fails fore and aft ought to be trimmed sharp at the same moment, in order to keep to the wind without losing any time. For the above-mentioned reasons, the main tack is got on board, and the sheet aft, when the wind is on the quarter.

TO VEEER A SHIP THAT HAS LOST HER FORE-MAST.

Run out the end of a cable or hawser over the lee-quarter, and buoy it up from the ground with empty casks, &c. in case of coming into shoal-water with little wind. This will assist the helm with such power as to make the ship veer and steer at pleasure.

A spare yard or boom, rigged out abaft the mizen-throwds, may guy the end of the cable or hawser more or less on either quarter, according as the ship may have occasion to fail. It may be easily shifted from side to side, and guyed out to leeward in proportion to the ship's griping, to answer failing upon both tacks; and, when failing before the wind, it may be secured over the middle of the stern, which will prevent the ship's broaching-to against the helm either way.

This would likewise much assist deep-laded bad-steering ships, and prevent their broaching-to; to which they are liable in spite of the best helmsmen, often occasioning them to lie-to, even with a fair wind. With a little contrivance, by blocks lashed to the rails on the quarters, to lead the guys fair to the steering wheel-barrel, it may be made to steer a ship that has lost her rudder. The invention of Capt. Edward Pakenham is, however, far preferable for this purpose.

TO VEEER WHEN LYING-TO UNDER A MAIN-SAIL.

Advantage must be taken of the ship's falling off to put the helm a-weather, and ease away the main-sheet roundly; and, when the ship has fallen off about 30° , let go the main bowline, and round-in the weather-brace, taking care to keep the sail full. When the
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ship is before the wind, get on board the main tack, and right the helm, to moderate her coming-to.

If, in the beginning, the ship is found difficult to veer, the fore stay-sail may be hoisted, and the sheets hauled well aft; but it is to be hauled down as soon as the ship is before the wind.

DEMONSTRATION.

Opportunity must be taken of the ship's falling off, because that motion of the ship gives her way, and makes her of course better disposed to gather way. For that reason, also, the helm is then put a-weather, (§. 50, 58,) and the main-sheet eased off roundly, (§. 49,) that only that part of the sail which is before the centre of gravity of the ship may be left to act. The main bowline is kept fast till the ship has fallen off 30° at least, and then let go directly, because the wind is then more easily kept in the sail, the velocity of the ship increased, and consequently the power of the helm (§. 58) and the movement of rotation is also accelerated. (§. 16, 17, 18.) By hauling in the weather-brace, you follow the wind with the sail; and, when the wind is right aft, that sail will be found square. To trim it, you have but to ease off the brace, and bring the tack on the same board as you take the wind; an operation for which you have full time sufficient, as, by righting the helm, you moderate the velocity with which the ship flies to the wind, since, by that action, the effect of the rudder is totally suppressed.

A SECOND METHOD.

Make fast a four-inch rope to the flings of the main-yard; and, when the ship comes-to, so as to shiver the main-sail, bring it down before the sail to the top-sail-sheet bitts, and let it be hauled tight and belayed. Then, as soon as she falls off, put the helm a-weather, and let go the main sheet. By these means, the lee-part of the sail no longer has any power to keep the ship to the wind, and
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the weather-part acting before the centre of gravity will cause her to veer faster than by the first method; though, in general, the first method will answer the purpose.

TO VEER UNDER BARE POLES.

The fore-stayfail must, if circumstances will allow it, be hoisted. (§. 31.) But, if that cannot be done, the head-yards are to be braced up as sharp as possible, and those abaft pointed to the wind. Then, if the ship veers, she will steer under the masts and ropes only. A number of seamen, sent up and placed close to each other in the weather fore-shrouds, will be found also of very great service.

TO BOXHAUL A SHIP, OR THE SECOND METHOD OF VEERING.

In this evolution, the most rapid execution is necessary. Briskly, and at the same instant, haul up both the main-sail and the mizen; shiver the main and mizen topfails; put the helm hard a-lee; raise the fore-tack; let go the head-bowlines, and brace about the head-yards sharp the other way; and let the jib and stayfail sheets go in the same instant. When the ship has fallen off 90° , brace the after-yards square, in order to give the ship a little way, and to help her (with the rudder, the situation of which must be changed) to double the point where all the sails shiver; and, when the wind is aft, you will proceed as in the method of "*Veering without losing the wind out of the sails.*"

If the circular motion of the ship, after she has fallen off 90° , continues pretty rapid, the filling of the after-sails, to give the

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ship headway, may be dispensed with; because she continues to turn by the effect of her helm, which must not be shifted, (§. 58,) since the vessel still continues her sternway. Therefore, after having veered a few degrees more, the wind will fill all the sails, and the ship consequently will have headway. (§. 35 and 43.) Then change the situation of the rudder, (§. 50,) to bring her before the wind.

In a case of absolute danger, when it might be necessary to go a-stern and fall off more rapidly, put the helm a-lee, brace all the sails a-back, observing not to brace the after-sails more than square, that they may not counteract the head-sails, which are braced sharp a-back to pay the ship's head off; because the effect of the after-sails, in this situation, is to impel the ship abaft in the direction of her keel; (§. 36;) which, with those forward, contribute to give her fresh sternway, in order to cause the ship to veer (§. 58) with greater celerity. The jib and fore-topmast stay-sail-sheets being hauled over to windward, will assist the ship in falling-off and going a-stern. (§. 31.)

When a ship is taken a-back, by bad steerage or a shift of wind, she may sometimes be brought on the same tack again, by instantly bracing sharp round the head-sails, and keeping fast the jib and stay-sail sheets. One must recollect, also, the after-sails are not to be touched (§. 45) till the ship has sufficiently fallen off; and, when that shall be the case, trim the sails and stand on as before. The rudder is to be used, as occasion may require, according to §. 50 and 58, whether the ship has head or stern way.

DEMONSTRATION.

This operation should be performed with the greatest alacrity, because it is only practised in critical situations; such as finding the ship unexpectedly too near the land, or because the ship misses stays.

The reasons for hauling up the main and the mizen sails, and shivering the mizen-top-sail, having been given before, we have

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only to add, that the reason why the main-topfail is shivered is, that, if it were kept full, it would bring the ship to the wind, (§. 41,) by shooting her a-head, so that she would almost be laid-to. If this fail were braced a-back, more than perfectly square or perpendicular to the keel, it would still keep the ship to the wind, since it would be braced the same way with the head-fails. Therefore, it would impel the after-part of the ship to leeward, (§. 44,) and act consequently against the power of the head-fails, which ought to cause the ship to veer rapidly, because they receive the wind on their anterior surfaces (§. 37 and 38) with a very great sine of incidence. It is therefore absolutely necessary to keep the after-fails shivering till the ship has fallen off 90° , or thereabouts; because, then, all the fails are trimmed and shivering in the same direction, since the head-fails were suddenly braced sharp a-back, in the beginning, to promote the ship's veering; and the after-fails were also changed at the same time, by bracing them by little and little to the wind, to keep them shivering, as the ship falls off. If the fails are well worked, they will all be found shivering at the same time; and then they no longer act on the ship, which will not double this point by the sole effect of the helm, for the helm was put hard a-lee in the beginning, to heave up in the wind with all possible expedition; but the ship, soon after getting sternway, falls off rapidly, both by the effects of her fails, and by that of her rudder, which is well disposed for this movement, (§. 58,) but has not always sufficient force to cause the ship to double the point where all her fails shiver; because the wind, being then on her quarter, acts on the whole machine to send her a-head; so that, if one ceased working here for a moment, the ship would be motionless for a time, having lost her sternway. To put her again in action, and to prevent her from driving more than is necessary to leeward, fill the after-fails, as mentioned above, to give her headway, in order that, by shifting the helm, (§. 50,) the wind may be quickly brought aft.

The jib and stayfail sheets are let go, because they tend to draw the ship a-head. (§. 31.)

Boxhauling is deemed the surest and readiest way to get a ship under command of the helm and sails, with the least loss of ground to leeward, when a ship refuses stays. The masters of sloop-rigged vessels, turning to windward in narrow channels, when they want but little to weather a certain point, run up in the wind till the headway ceases, then they fill again upon the same tack: this they call making a *half-board*. Thus a ship, in boxhauling, may be said to make two half-boards, first running with her head, then with her stern, up in the wind; by which two motions a ship rather gains to windward.

TO CLUBHAUL A SHIP.

Clubhauling is practised when it is expected that a ship will refuse stays upon a lee-shore. Place the hands to their stations for putting the ship about, and some by the lee-anchor; then put the helm down, and if the ship make a stand before she brings the wind a-head, let go the anchor and haul the main-sail. When the wind is a-head, cut the cable, and the ship will cast the way required. The after-sails being full, let go and haul.

ANOTHER METHOD.

Bend a hawser to the kedge-anchor on the lee-bow, and bring the end into one of the after-ports, or over the taffarel. Let go the anchor, brace up all sharp the contrary way, put the helm a-lee, and haul in briskly on the hawser. As soon as she gets headway, cut or slip the hawser, and carry a press of sail.

OF LYING-TO, &c.

OF LYING-TO IN FAIR WEATHER.

Lying-to is the art of disposing the sails in such a manner, that, counteracting each other, they render the ship as it were, for a time, immoveable.

This is seldom practised but under the three topfails; yet it is indifferent whether the fore or main topfails be braced a-back or kept full; because, as these two fails have surfaces nearly equal, they have nearly the same power either to stop the ship's way, or to cause her to run a-head. When these two fails act together, or one against the other, one always tends to pay the ship's head off, and the other to keep her to the wind. (§. 32, 37, 41, and 44.) But there are other considerations to be attended to, when necessity requires this operation to be practised.

TO LIE-TO TO WINDWARD OF A SHIP, SO AS NOT TO DRIFT NEAR HER.

The main-topfail must be braced sharp a-back, keeping the fore and mizen topfails full; because the wind acts with a very small sine of incidence on a sail when full, in comparison to what it does
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when braced sharp a-back : so that the fore-topfail, being full, draws the ship a-head, and the effect of falling off is opposed by the main and mizen topfails. She will of course not fall off much ; nor will her lee-way be very considerable ; for the ship is well kept to the wind, by the disposition given to her fails.

TO LIE-TO UNDER THE LEE OF ANOTHER SHIP.

The fore-topfail ought to be braced sharp a-back, the main and mizen topfails kept full, because these two last-mentioned fails tend to give the ship headway, and keep her to the wind : they may be assisted by the mizen, which will oppose the falling off occasioned by the fore-topfail. Thus, should the ship to windward fall off violently, or drift too much, you are more ready to veer short round, and avoid being boarded ; because the fore-topfail being braced sharp a-back, the impulse of the wind on it is much greater than if it were full ; and it is well disposed to veer suddenly, as soon as the power of the other fails is suppressed.

TO BRING-TO WITH THE FORE OR MAIN TOPSAILS A-BACK TO THE MAST OR FILLED.

Either the fore or main topfail must be braced sharp a-back, and the lee-bowline hauled up a little : the other two topfails trimmed sharp ; with the mizen hauled out, and the helm a-lee.

If you bring-to with the fore-topfail to the mast, the head-yards may be only laid square. Then the wind will act obliquely on the fail, and the ship will fall off but little, because its effect is in the direction

direction of the keel from forward aft, and the sails abaft keep the ship to. The main-top-sail may be worked in the same manner, if you wish not to expose yourself much to the wind.

DEMONSTRATION.

It has already been demonstrated, that if the fore or main top-sail be braced sharp a-back, while the other remains full by the wind, the ship stands as if it were immovable, for their actions are absolutely contrary with respect to the centre of gravity, (§. 18,) and very nearly equal; therefore, in this situation, the ship can but drive to leeward at the rate of about half a league an hour.

TO BRING-TO WITH THE THREE TOPSAILS A-BACK.

The jib and stay-sails being hauled down, brace sharp round at once all the sails you wish to lie a-back in hauling up the lee-bow-lines, the better to expose the sails to the action of the wind: haul out the mizen, and put the helm hard a-weather.

DEMONSTRATION.

The jib and all the stay-sails are hauled down, because they are before the centre of gravity (§. 31); and the head-sails, being braced sharp a-back, have force enough (§. 37) to balance the effect of those abaft (§. 44); which, being braced in the same manner, receive the wind with the same sine of incidence as those forward. But, as in that situation the head-sails, having more power to cause the ship to fall off (§. 12) than those abaft, being a little becalmed by those forward, have to bring her to the wind, the mizen

is hauled out (§. 40), and the helm is put a-weather (§. 58), because the ship goes a-stern with all the topsails to the mast. In this situation, then, the sails, assisted by the rudder, act the one against the other, and balance reciprocally their effects of springing the luff and falling off; and, though the ship goes a-stern and drifts a great deal, she is laid-to; because, in that situation, she yields but with great difficulty to the impulse of her sails, on account of the resistance of the water (§. 5), opposed to the very great surface of her bottom under the lee.

If there were occasion to keep the mizen topsail full, it might be done with advantage; because the effect of its acting against the other sails is so inconsiderable, that it cannot admit of a comparison, as its surface is hardly half that of the main topsail.

If it be desired to go a-stern without falling off, the head-sails are to be laid square only.

TO FILL, WHEN LYING-TO WITH THE FORE TOPSAIL TO THE MAST.

Brail up the mizen, hoist the jib and fore-topmast stay-sail, shiver the main and mizen topsails, and, when the ship has fallen off 20° or 30° , fill the fore-top-sail, which was a-back before, and stand on.

DEMONSTRATION.

The mizen is hauled up, that its effect of keeping the ship to the wind may cease (§. 40). The jib and fore-topmast stay-sails are hoisted, to help the ship in falling off (§. 31). The main and mizen topsails are shivered, because their effects are contrary (§. 41 and 44) to the movement expected from the ship. Every thing, therefore, which causes her keeping to the wind, ceasing to act,

act, and all that promotes her falling off now operating, it follows that she must fall off with a rapidity so much the greater, as the helm is still a-lee (§. 58). The ship goes a-stern, since her head-fails are braced a-back, and her after-fails so disposed and shivering, that, when she has fallen off sufficiently, the head-fails fill, and you stand on directly.

TO FILL, WHEN LYING-TO WITH THE MAIN-TOPSAIL TO THE MAST.

Brace sharp and briskly the fore-topfail a-back; shiver the main and mizen topfails; hoist the jib and fore-topmast stayfails, and brail up the mizen, all at the same time; and, when the ship has fallen off 20° or 30° , fill the fore-topfail, and stand on.

If you are obliged to keep the wind on the same tack as that on which you are lying-to, you have only to right the helm, fill the topfail which is a-back, and trim it sharp, to continue your course.

DEMONSTRATION.

The fore-topfail is braced sharp a-back, in order to cause the vessel to fall off more readily, as then it receives a very strong impulse from the wind (§. 37). The rest of the demonstration will be found in the preceding.

A SECOND METHOD.

Trim the topfail which was to the mast, in order to give the ship way through the water, and be able to tack, or run large, ac-

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cording as may be found necessary. But this method is very tedious, unless you mean to heave in stays; in which case it will be most expeditious.

A THIRD METHOD.

Shiver the main and mizen topfail, keeping the fore-topfail full, righting the helm, and running up the jib and fore-topmast stayfail at the same time. As soon as the ship has fallen off enough to get headway, fill the after-fails, and keep the ship in the direction you mean to follow. It is easily seen that this method, though the most common, is not the most expeditious, when you have to veer considerably.

TO FILL, WHEN LYING-TO WITH ALL THE SAILS TO THE MAST.

Brail up the mizen, lay the after-yards square, and shift the helm a-lee. When the ship has fallen off sufficiently to fill the after-fails, those forward are then to be braced about and trimmed full also, in order to stand on.

DEMONSTRATION.

The mizen is brailed up, because its effect is to keep the ship to the wind (§. 40). The after-yards are laid square, because then they give the ship sternway (§. 36), which causes her to fall off, since they increase her velocity in the last-mentioned direction, the helm being a-lee so as to turn the stern to windward (§. 58). The head-fails are braced about and filled at the same time as the after-

fails

fails are, that the ship may not be as it were laid-to, and that she may get headway to continue her course.

OF LYING-TO IN A GALE OF WIND.

To lie-to when it blows hard, keep as close to the wind as possible under some one sail well trimmed, with the helm lashed a-lee as much as may be requisite for the ship; and, as ships commonly bring-to from the stress of contrary winds, care should be taken to heave-to under such sail as will least strain the ship; because there are some ships which lie-to better under the fore-sail than the main-sail, others are more easy under the main-sail, some under a mizen, and many vessels lie-to best under a main-stay-sail.

LYING-TO UNDER A FORESAIL.

This is advantageous for veering (§. 32) when you are well to windward; but it augments the lee-way, and is more subject to break the sea on-board, on account of the ship's continual falling off: because, in that movement, she gathers way by yielding to the impulse of the gale, and is afterwards recalled to the wind by the helm (§. 50); so that, in springing the luff, she meets the wave which comes from to windward.

LYING-TO UNDER A MAINSAIL.

The ship does not, in this situation, fall off so easily as in the last-mentioned mode, because its effect passes abaft the centre of gravity of the ship (§. 41); but it keeps the ship more to the wind, and consequently occasions less lee-way.

LYING-TO UNDER THE MIZEN.

Under the mizen ships keep better to the wind than under any other sail, because it is farther abaft the centre of gravity (§. 40) than any of the rest; consequently ought to keep the vessel from drifting more than any of the others; but is inconvenient, should you have occasion to veer suddenly.

LYING-TO UNDER THE MAIN-STAYSAIL.

Under the main-staysail a ship will not make so much lee-way as under a fore-sail, because its effort passes very near the centre of gravity; but it will however cause her to drift more (§. 31) than the main-sail (§. 41): so that this mode of lying-to is a mean between the two others, and is preferable when it blows strong enough for that sail to support the rolling of the ship. It ought likewise to be preferred, because the ship will veer under that sail, the action of which passes at a small distance from the centre of gravity

gravity (§. 31), and the power of which overcomes the resistance which all ships meet from the fluid under their lee; a resistance which always gives them a great inclination to fly up in the wind, when it blows hard, or when under a heavy press of sail.

LYING-TO UNDER THE FORE, MAIN, AND MIZEN, STAY-SAILS.

All the preceding modes of lying-to have their peculiar faults; but the preferable way is under the fore-stayfail, the main-stayfail, and mizen-stayfail; because, under these sails, the ship will steer (§. 46), and is in a better situation for veering than under any other fail; for, only haul down the mizen-stayfail, and put the helm a-weather; when the two other sails, being before the centre of gravity, (§. 30 and 31,) will cause her to fall off; she will then soon gather way and steer easily.

Should the gale continue very hard, and one of these stayfails be blown away, the loss is not of much consequence, as the courses, in case of an emergency, are ready to set; whereas the courses are not so readily replaced when lost. This mode, therefore, appears preferable in every respect,* whether you wish to veer or keep your wind: because, if the ship does not sufficiently keep the wind, you may haul out the balanced mizen (§. 40), or take in the fore-stayfail (§. 31), or even the main-stayfail. One of these stayfails, before the centre of gravity of the ship, is sufficient to make her veer as soon as the after-ones are suppressed. There are, besides, these following considerations for so doing: The ship will carry sail better; because, as the centre of effort of those on her is very low, she drifts less, holds a better wind, and goes faster through the water (§. 25 and 46); and these three or four sails
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* Should the sea run too high for the lower stayfails to keep the ship steady, a close-reefed main-topfail (particularly if it has four reefs in it to come close down to the cap) will be found to answer the purpose admirably.

are so situated as to give the whole body of the ship play, which will strain her less than when under one single sail, which cannot by itself work it from aft forward.

DEMONSTRATION.

The object of lying-to being to keep to windward as much as possible, when foul winds and tempestuous weather prevent you from pursuing your course, it follows, as much sail should be carried as is consistent with safety; and, as you are often unable to set more than one sail, it is trimmed sharp, that the ship may keep her wind as much as possible. It is likewise for this reason that the helm is at the same time put a-lee; because the ship, having but very little way, (§. 46,) falls off, by yielding from time to time to the impulse of the wind, which unceasingly acts on her; but, as soon as she has fallen off, she is brought-to again by the effect of the rudder (§. 50), which must act upon her if the water has the smallest power upon it.

The same happens in lying-to under the three stay-sails, (though the ship makes more headway under any other sail,) because the effect of these sails is better distributed (§. 46) than when one only is set; notwithstanding they have not power enough to procure the ship much velocity, nor to make her steer properly: the helm is therefore put a-lee as in lying-to under any other sail. It is always more advantageous to keep the ship under way and lively, than to let her lie, at the mercy of the wind and waves.

When the wind is so violent that no sail can be carried, you lie-to a-try; that is to say, under bare poles and ropes, which serve instead of sails, and lash the helm a-lee as usual.

OF SOUNDING IN FAIR WEATHER, WHETHER CLOSE-HAULED
OR GOING LARGE.

CLOSE-HAULED.

If close-hauled, brail up the mizen and mizen-stayfail, let go the main-sheet that the sail may shiver, put the helm a-lee, and back the mizen-topfail by bracing it square. The head-fails, as well as the jib and stayfails, are to be kept in their first situation; recollecting to haul tight and belay the lee-braces. When the ship has nearly lost her headway, though continuing still to come to the wind, you catch that moment to heave the lead, and it is to be hauled in again with all possible dispatch. To fill again, haul aft the main-sheet, trim the mizen-topfail, and right the helm.

GOING LARGE.

In going large, you have only to put the helm a-lee, to brail up the mizen, and to belay the lee-braces quite tight, to prevent the yards having too much play when the sails are shivering. It is impossible to tack in this situation, as the jib and head-fails are always in action (§. 31); and the square-fails, soon coming to shake, on account of their sheets not being tacked, they lose all their power, and the ship is soon at a stand.

DEMONSTRATION.

The mizen and mizen-stayfail are brailed up, because their effect to bring the ship to the wind would be too powerful (§. 40). For the same reason, the main-sheet is let go (§. 41), though there is another reason for it, which is, that it destroys the equilibrium
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that existed between the sails forward and the sails aft (§. 46 and 49); whence the rapidity of sailing is diminished, as well as the effect of the helm, which acted (§. 50) to bring the ship to the wind, while at the same time it opposes her velocity (§. 59). The mizen-topfail is braced a-back, to impel the ship a-stern in the direction of her length (§. 36); so that her headway, being now much diminished, the ship, by the effect of the rudder, ranges to the wind so far as to shake the main-topfail and the sails on the foremast, which, to that very moment, had acted to keep up the celerity of sailing (§. 32 and 41). But, as the effect of the rudder is very faint, since the velocity of the ship is greatly diminished (§. 58) when the sails have lost their action, the ship must stop, and is not able to come sufficiently to the wind, to bring her about, because the jib and stayfail sheets, being hauled aft, oppose the effect of the helm; so that she rests, as it were, motionless for an instant, which must be seized to throw the lead with the greatest dispatch; because, should the ship fall off by the effect of her jib and stayfail, which are the only ones in action, the other sails might suddenly fill and give her headway, which would prevent you from getting soundings, were you too dilatory in throwing the lead. Whether you do or do not find any bottom, haul in your line as fast as possible, and seize the opportunity of the ship's falling off to fill and stand on again.

If the ship, in spite of the disposition given her, should come head to wind, (which could only happen from her having preserved some velocity,) the helm must be kept a-lee, but the head-fails should quickly be laid square, and the jib and stayfails hauled down; then the ship will soon after be found to veer.

ANOTHER METHOD PREFERABLE TO THE FORMER.

GOING LARGE.

Brace the head-fails square, haul down the jib and stayfails, without stirring the after-fails, and put the helm a-lee. While the ship has still a little headway, heave the lead from the place where
you

you haul it in; that lead will go first a little a-stern; but the ship, being head to wind, will soon herself go a-stern right upon the line; and, as the helm is a-lee, the ship easily veers. But, if you wish to keep her to longer, right the helm and haul the mizen out, to prevent the ship's falling off.

If you have studding-sails set, they must be hauled down, particularly the lower ones; because, should the wind take them a-back, their power on the boom might bring the ship round entirely; for, they act on a lever without the ship, the fulcrum of which is on the outside of the vessel before the centre of gravity. If, however, the helm is continued a-lee till the ship falls off, she will not come about, because then the vessel goes a-stern with great velocity, and the rudder acts powerfully to make her veer; but the fact is, that the ship will go a great deal sternway, and continue so much longer.

CLOSE-HAULED.

If close-hauled, or a very little from the wind, the helm is to be put a-lee; and, the instant the sails are taken a-back, the head-sails are to be filled by briskly bracing them square, without waiting for the wind being right a-head; then, a little before the ship has lost her way, heave the lead from the place where you haul it in, and then proceed as before.

ON SHIPS DRIVING.

When it happens that there is not sufficient room to work in a tide's way, through a crowd of ships, or in a narrow channel, but that a ship must drive by the help of the tide, it may be done, provided the tide be strong enough, in proportion to the wind. This art consists of keeping the ship in a fair way, by a management of the rudder and the sails.

TO DRIVE TO WINDWARD, WHEN THE WIND IS AGAINST THE TIDE.

If the channel is sufficiently broad, the ship should be drifted broad-side to the wind, as the tide will then have the greatest power on her; and, could the ship be backed a-stern or shot a-head at pleasure, she might be kept drifting upon the same tack with safety; but ships in a tide's way can never be backed so far a-stern as they will shoot a-head. At the first of a stern-board a ship will go briskly a-stern, but will soon fall off, and drift with the wind abaft the beam, forging a-head; for this reason she must be drifted with the helm a-lee. It follows, as a ship will shoot more a-head than she can be backed a-stern, that she will at length arrive at the opposite shore, when she must be stayed or veered, and drifted upon the other tack. If she is to be stayed, (which is preferable, because

because less drift will be lost by it,) let the sails be filled in time, to give the ship sufficient headway to bring her about; then put the helm a-lee. Should she come about, the sails and helm, having now a proper position for a stern-board upon the other tack, need not be touched till her sternway ceases, when the helm must be shifted a-lee; but, should the ship refuse stays, then brace sharp round the head-yards, and boxhaul her, by which method she will lose much less drift than by veering.

If the ship, now drifting broad-side, is approaching a narrow channel, where drifting in this position, she must be veered and dropped stemming the tide, stern foremost. In this case, that the drift may be as much as possible, it will be necessary to take in sail, and reduce the ship's headway till she has only steerage-way left; thus a vessel may be dropped through a fleet of ships at anchor without danger.

TO DRIVE, WHEN THE WIND IS ACROSS THE TIDE.

Should the wind be a little across the tide, a ship may be easily drifted in the fair way, with her head towards the weather-shore; for thus it will be found that she can be backed and filled at pleasure, and generally be drifted with the sails shivering, in which position they oppose least power to prevent the drift.

It frequently happens in serpentine rivers that the tide sets across; in this case the ship must be drifted with her head to the side from which the tide sets. These sets are best discovered by observing the opening or shutting of two objects in the direction of the channel.

ON BENDING SAILS.

TO BEND A COURSE IN FAIR WEATHER.

Stretch the sail a-thwart the deck, the starboard-side of the sail to the starboard-side, the larboard to the larboard-side; then bend yard-ropes to the ear-ring cringles, and make fast the head ear-rings a few feet up upon the yard-ropes. The bunt-lines, leech-lines, clue-garnets, and all the geer bent, make fast a rope-band to each bunt-line and leech-line leg, that the men may be enabled to catch the head of the sail from the yard. Now man well the yard-ropes, bunt-lines, leech-lines, and clue-garnets, and run the sail up to the yard. The sail aloft, send the hands up to bring it to, and let them haul out the weather ear-ring first, then the lee; and, if it is a new sail, let them ride the head-rope to stretch it. The sail being hauled square out upon the yard, make fast the rope-bands, keeping the head of the sail well upon the yard.

TO BEND A TOPSAIL IN FAIR WEATHER.

Overhaul the leeches of the sail, put in the ear-rings, bend the bowline-legs, lay out the clues, and open them if necessary, and make

make the fail up snug again; then round down upon the lee top-fail-haliards till the weather fly-block is high enough to bring the fail up over the guard-iron: then rack the tie over to the weather-rigging. Now pile the fail upon flings, with the lee-side uppermost; hook on the topfail-haliards, and run the topfail up into the top; then stretch the fail round the fore-part of the top, bend the jeer, and make fast the head ear-rings a few feet up upon the reef-tackle pendants, with a rope-band or two to each bunt-line leg. The jeer being bent, man the reef-tackles, bunt-lines, and clue-lines, and haul out the fail. Now let the hands lay out upon the yard, and haul out the weather ear-rings first; then haul out to leeward, and ease off to windward till the fail is square, when make fast the rope-bands, keeping the head of the fail well up upon the yard.

UPON

UPON SETTING AND TAKING IN SAILS IN BLOWING WEATHER.

TO SET A MAINSAIL.

Before the fail is loosed, let the double block of a tackle be made fast to the weather-clue, and the single block be hooked low down upon the chefs-tree, and the fall led aft. Then man well the main tack and fall at the same time; and, when the fail is loosed, ease away the weather clue-garnet, let go the bunt-lines and leech-lines, bowse down upon the tackle, and take in the main-tack: the main-tack being down, haul aft the sheet, brace up the yard, and haul the main-bowline.

TO SET A FORESAIL.

A forefail is set after the same manner as a mainfail; but, as the fore-tacks generally lead double, they are a sufficient purchase without the aid of a tackle to the weather-clue.

TO SET A TOPSAIL.

Let a tackle be in readiness to clap on either sheet, as may be required. First, man the lee-sheet; and, the fail being loosed, ease
down

down the bunt-lines and weather clue-line, and haul home the lee-sheet; then haul home the weather-sheet, hoist the sail, and brace up as required.

Should the wind be quartering, the lower and topfail yards should be braced well into the wind, before the sail is sheeted home.

TO TAKE IN A COURSE.

Man well the weather clue-garnet, ease off the tack and bowline, and run it up; then man the lee clue-garnet, bunt-lines, leech-lines, and weather-brace; and, being all ready, ease away the sheet, haul up the clue-garnet, bunt-lines, and leech-lines, and round-in the weather-brace, till the yard is pointed to the wind. Then haul tight the trusses, braces, lifts, and rolling tackle, and let the hands furl the sail.

TO TAKE IN THE FORESAIL IN THE TIME OF VEERING.

When the ship begins to veer, the yard being kept braced sharp up, let go the tack and bowline, and haul up the weather clue-garnet. When the ship is nearly before the wind, the bunt and leech lines, and the other clue-garnet, may be hauled up; and, if the situation admits of it, and occasion requires, the ship may be steered with the wind on the quarter, till the sail is secured.

TO TAKE IN A TOPSAIL.

There are many opinions upon the best mode of performing this. Some approve of clueing up to windward first, and others to leeward. If the weather-side is to be clued up first, the weather-brace must be rounded well in, and the yard got close down upon the lifts, otherwise the lee-rigging will be in danger of being carried away by the great pressure of the lee yard-arm. If the weather-brace can be rounded well in, and the yard be got close down, it will be best to clue up to windward first, for thus the fail may be taken in without a shake; but, if the weather-brace cannot be hauled in to ease the yard off the lee-rigging, recourse must be had to clueing up to leeward first. In this case, it will be best, if hands can be spared, to man both the clue-lines, bunt-lines, and weather-brace, at the same time; thus, when the lee-sheet is eased off, the weather-brace may be hauled in with ease, and the yard laid to the wind; and, when the lee clue-line is half up, ease off the weather-sheet, and run up the weather clue-line; then haul tight the lee-brace, bowse tight the rolling-tackle, and furl the fail.

TO TAKE IN A JIB.

Man well the down-haul, let go the haliards, ease off the sheet, and haul down briskly; and, when the fail is close down, ease away the out-haul, and haul the fail in to the bowsprit-cap; then let it be stowed away in the fore-stayfail netting.

TO HAUL IN A LOWER STUDDING-SAIL.

To haul in a lower studding-sail, blowing fresh, lead one of the sheets clear aft, and man it well; then lower away briskly the outer haliards, to spill the sail; ease off the tack, run in upon the sheet, and lower away the inner haliards as required.

TO HAUL DOWN A TOPMAST STUDDING-SAIL.

Man well the deck-sheet and down-haul, ease off the yard-sheet, and haul the yard close out to the tack-block; then ease away the tack; and haul down both upon the deck-sheet and down-haul.

TO BRAIL UP AND HAUL DOWN A MAIN-TOPMAST STAY-SAIL.

Man well the lee-brail and down-haul, having a few hands to gather in the slack of the weather-brail; then let go the haliards, ease off the sheet, and haul down and brail up as briskly as possible. When the sail is down, let go the tack, and stop the sail over to the lee fore-rigging.

TO BRAIL UP A MIZEN.

Man well the lee-brails, and in particular the throat-brails, which should have a whip-purchase; ease off the mizen-sheet, and brail up briskly, taking in at the same time the slack of the weather-brail. After the sail is hauled up, stop its foot by passing the gasket round to leeward, which will spill it.

TO TAKE IN A TOPGALLANT-SAIL.

The lee-sheet must be started first; for, if the weather-sheet is first eased off, the yard will fly fore-and-aft.

TO UNBEND A COURSE.

First furl the sail, then cast off the rope-bands, and make them fast round the sail, clear of the gaskets. When the rope-bands are all off, ease off the lee ear-ring, and lower down the sail; and, when the people upon deck have got hold of the lee-part of the sail, ease away the weather ear-ring.

TO UNBEND A TOPSAIL.

First cast off the points of the reefs, keeping fast the ear-rings; then furl the sail, and cast off the rope-bands, which make fast round the sail, clear of the gaskets. After this, cast off the lee ear-rings, and haul the lee-side of the sail into the top; then haul in the weather-side. Now unbend the reef-tackle pendants, bunt-lines, and bowlines; bight the sail snugly up together; and send it down by the clew-lines to windward or leeward, as most convenient.

ON SCUDDING OR BEARING AWAY IN A STORM.

When the waves run high, and sudden necessity requires to bear away, it should be considered that the lower sails forward, which the ship may be veered under when she comes before the wind, may be becalmed by the height of the waves breaking violently against the stern; and that therefore a close-reefed main-top-sail should be set to catch the wind, because it is a loftier sail, and may always be kept drawing full above the waves. This increases the ship's headway so much, that the waves will not strike her abaft with so great a velocity as when her headway is less.

Hence it follows, that, when going to scud before high waves, the close-reefed main-top-sail should be the last square-sail taken-in in a laboursome ship.

OF A SHIP OVERSET ON HER SIDE.

A common but not always a certain method to recover ships from this dangerous situation, is to cut away the masts: however, as this expensive method may fail, stopwaters only, on the lee-quarter at sea, may cause the ship to veer; or, where there is ground, an anchor or anchors, dropped from the lee-bow, may bring the wind a-head, and take the sails a-back, so as to cast the ship on the other tack, and bring her upright.

ON

ON CHASING.

A vessel that chases another ought to have the advantage of sailing. We shall therefore suppose this to be the case; because, were the ship chased as good a sailer as the chaser, she never could come up with her, if they manœuvred equally and at the same time. It is then useless to chase a ship over which you have not the superiority in sailing, unless it be found that she does not know how to take the benefit of her equality.

To know if your ship sails quicker than your adversary, you must get on the same tack, under the same sails, and keep the same course with the vessel you wish to chase, and set her exactly with a compass. If you sail best, the chase will soon be drawn a point more aft; but, if she has the advantage, you will in a short time bring her a point farther forward: if you sail equally, she will remain on the point you set her at first.

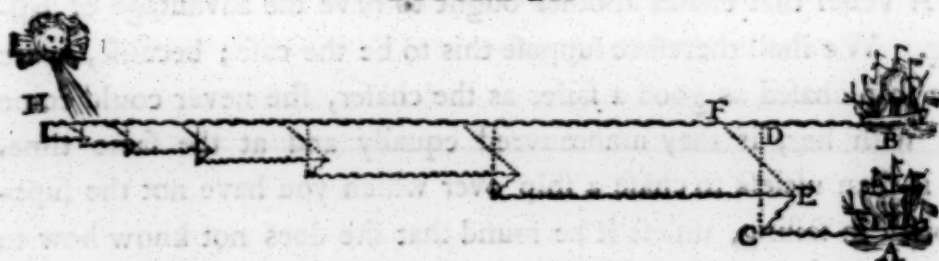
TO CHASE A SHIP WHICH IS TO WINDWARD, AND TO JOIN HER IN THE SHORTEST METHOD.

When the chaser is to leeward of the vessel he means to pursue, he ought to run on the same tack as the enemy, till he brings her to
bear

bear exactly perpendicular to his course, if he has not however already passed that point: then tack and continue the second board till he brings the chase again perpendicular to the direction on which he is standing by the wind, and he must then heave about again; always continuing the same manœuvre, by tacking every time he brings the chase perpendicular to his course on either board. In this manner, the chaser will, by the superiority only of his sailing, join the other by the shortest method.

DEMONSTRATION.

FIGURE 20.



When the ship *A* (*fig. 20*) chases the ship *B*, which is three leagues to windward, *A* having one-fourth of advantage in sailing, the chaser is not to tack till he reaches the point *C*; because then the ship *B* will be right on his beam at the point *D*. He then runs on the tack *C E*, till he brings the chase again perpendicular to his course at the point *F*. The ship *A* is to continue working thus every time she brings the vessel *B* right a-breast of her, whether the chase continues on the same tack or not; and thus the chaser will join the other at *H*, so that she will be able neither to change her course nor fly from him.

You continue on the same tack as the enemy, when first seen, in order to lose no time; because you will always bring the ship you are in chase of right on your beam, when you have a superiority of sailing, whatever may be the track she is on, provided you are careful not to pass that point; but, if perchance you should, you must get on the other tack with all possible dispatch.

The

The chafer heaves about as soon as the vessel he is in pursuit of is on his beam; because she is, at this time, at the shortest possible distance, if he chases on the same tack and steers the same course with the vessel chased. If the chafer runs on a different tack from the vessel chased, he is still to tack when the latter is on his beam, because the distance is the least possible between them on the different boards they hold.

This mode is preferable to all others, it not only being the shortest, but because you force the chase to fly from you close upon a wind, pressing her more and more from the leeward, by never passing the point at which the distance between the two vessels, in plying to windward, is the shortest possible.

OBSERVATIONS FOR THE SHIP TO WINDWARD, WHICH IS CHASED.

The weather-ship, which flies, will always be joined by the chafer, since it is granted that she does not sail so well as the pursuing vessel. It is therefore her advantage constantly to keep one course without losing time to heave about, as tacking cannot be so favourable to her as to her adversary, whose sailing is superior.

If the chafer should mistakingly stand on a long way, and tack in the wake of the chase, the best thing she can do is to heave-in stays, and pass to windward of him on the other tack, unless you suppose your vessel would have a large superiority. If the chafer persists in tacking in the wake of the other ship, the chase will be very much prolonged.

TO CHASE A SHIP WHICH IS TO LEEWARD.

When to windward of a vessel you wish to chase, keep the ship away, to cut her off; and, steering continually on that course, you come at last together at the point where the courses run by the two vessels intersecting each other. This will be exactly executed by the chasing-ship, if, in the course she has chosen, she constantly keeps chase on the same degree of the compass as at the beginning of the pursuit. This principle applies equally to all the courses which the retreating ship steers; for over-taking can only be obtained by keeping on a strait line, which is the shortest possible that can be drawn between any two points.

If you take another course than that which keeps you in the same point of bearing you were in with respect to the vessel pursued, at the beginning of the chase, you would fail, by being either too far a-head or too far a-stern; that is to say, if the chaser keeps his wind too close, he will be too much a-head, and consequently prolong the chase; and, if he keeps too much away, he will be too far a-stern. These are the only two considerations to be made for the performance of this manœuvre; considerations which are easily observed, and corrected with an azimuth-compass; for, when you see that at the end of a certain time you bring the chase more aft than her first point of bearing, it is evident you keep your wind too much; if, on the contrary, you draw her forward, it is a proof that you keep too much away. These errors are easily corrected, by steering, for the first case, so as to see that the chase is always kept exactly on the same degree of the compass; and, for the second, you keep your wind a little more, till you see that you rest on the same point of bearing with respect to one another. Then, it is evident, you chase by the shortest and most certain method, since you reach the chase, in running on a strait line.

OBSERVATIONS FOR THE SHIP TO LEEWARD, WHICH IS
CHASED.

She ought to run on the course that will carry her most immediately from the chaser. Some vessels have more advantage in going large than others; some with the wind right aft; and others, again, are to be found which go best close-hauled. So that attention should be paid to the known qualities of a ship, in order to take the most advantageous and convenient directions capable to effect a retreat. It is, however, nearly certain, that, if the chase does not sail at least at an equal rate with the chaser, whatever manœuvre she may practise, she will at length be overtaken by a skilful chaser adhering to principles.

F f

OF

OF BOARDING.

Boarding is the art of approaching the ship of an enemy so near, that you can easily, and in spite of him, throw on board the grapplings, which are fixed on the lower yard-arms, at the forecastle, gangways, &c. for the purpose of being thrown into the enemy's ship, as soon as along-side, in order to confine the vessels together, and give the people an opportunity of getting on board, to carry the adverse ship sword in hand.

TO BOARD TO WINDWARD, OR TO AVOID BEING BOARDED.

If it be desired to board a ship which keeps her wind under an easy sail; or that does not shorten sail, but over which the boarding vessel has the advantage of sailing; she must get on the weather-quarter of the ship she means to board, within half a pistol-shot. She should then begin the action, and continue it with vivacity, to cover her manœuvre by the smoke of the cannon and musquetry of both ships; then, under the cover of this cloud, let her make more sail if she has not way enough, in order to augment the velocity of the ship and the rapidity of her movements,
that

that she may more readily lay on board her enemy, on the weather-side, either exactly a-breast or a little abaft. This is very easily executed, by edging down suddenly upon her; so, however, as not to be raked by the enemy's fire. The ship boarded by this manœuvre can hardly suspect the design but at the moment when, or very little before, the grapnels will be on board of her. In this situation the boarded vessel has but one doubtful expedient to try, and which even will be of no service if the boarder observes her well. For, the moment she braces sharp a-back her head-sails, to cause the ship's falling off, (§. 37,) and squares those aft (§. 36) to give her sternway, the boarder has only to perform briskly the same manœuvre, and they will then be both as near for boarding as before, provided the boarding-ship feels quickly the impulse of her sails and helm, which ought to be put a-weather (§. 50) and kept so till the ship's headway ceases, when it is to be put a-lee (§. 58) to assist her in falling off, in manœuvring as in boxhauling, in order to board the enemy to leeward; for, the boarder ought to be on the quarter of the other; since, at the moment the two ships were right before the wind, she who was directly to windward, and wished to board, had only to continue her movement of rotation, and render her velocity equal to that of her adversary, by shortening sail in order not to pass her. If, therefore, the circular motion is kept up by the boarder, which at first caused him to fall off, and now brings him to the wind on the other tack, he will join the enemy to leeward; for, it is evident that, if this motion of turning be more rapid than that of the ship which wishes to avoid boarding, the boarder will close her before she can range to the wind on the other tack, since the boarder comes round with greater celerity. However, if the ship which fears boarding was pressed thus closely, she could make no other attempt than to throw once more all her sails to the mast, by bracing them only perpendicular to the keel to give her sternway, (§. 36,) and putting the helm a-weather, to keep her to the wind, as soon as her headway ceases; (§. 58;) observing that, she being to windward, this manœuvre may cause her to drive on the boarder, as he is then watching for her under her lee. As there is no other resource, necessity obliges her to this expedient; because, if the ship which is attack-

ed could go a-stern with sufficient velocity, she might let the boarder pass a-head, veer under his stern, and rake him, if he is not as quick as the other to foresee this manœuvre, and as nimble in manœuvring in the same manner as the enemy's ship: because, the great velocity with which he comes to the wind and goes a-head, (his sails being still full,) puts him in this bad situation, which may prevent his persisting in the inclination of boarding. It is however very clear that the boarder will attain his purpose, if he takes care to throw all his sails a-back at the same time as the ship to windward; because, the attacked ship dropping to leeward, and having sternway first, approaches a little the boarder, who has still preserved his position on the quarter, and longer kept his luff, by having gone a-stern somewhat later than the weather-ship. It must be farther observed, that when the two ships are right before the wind, if the vessel which fears boarding moves quicker to the wind than the one which attacks, she will avoid it, as the retreating ship will be close to the wind before the other, and able to get a-head of her by making all sail to keep her wind, or to heave in stays and get upon the other tack. But, it must be considered that this last movement is disadvantageous; as, by so doing, it will present the stern to a ship, which no doubt will take advantage of that situation, and rake her; which might be more destructive than a well-opposed attack by boarding.

There is, however, no doubt that if the ship inclined to board sails better than the other, it will always be in her power to execute that design, if she is manœuvred as the ship which flies.

TO BOARD TO LEEWARD, WHEN CLOSE TO THE WIND, OR
TO AVOID BEING BOARDED.

In order to execute this manœuvre, the boarder is to come within pistol-shot, close in the wake, or, at most, to the weather-quarter,

ter, of the ship he means to attack; taking care to continue steering so as not to be raked by any of the guns which belong to the quarter he stands on. Then, to come up with his adversary, he must edge away a little, and range round aft, so close upon the enemy's lee-quarter, that his cat-head may almost touch her quarter-gallery. Now, when you have shot sufficiently a-head, your ship being parallel to your adversary's, so as to bring your fore-castle a-breast of your enemy's main-mast, the mizen and mizen-stay-sail sheets are to be hauled well aft, the helm put hard a-lee, and the head-sheets let fly; then, your ship, coming rapidly to the wind, (§. 40, 50, and 51,) shivers her sails, and closes the opposing vessel side to side. This manœuvre is infallible when you have the advantage of sailing, provided very great attention is paid to it. But great attention is necessary; because, if at this moment the weather-ship, which wishes to avoid the boarding, either sets her courses, or lays all those flat a-back which she had set, she may perchance break the grapnels if you have neglected to trim your sails in the same manner as hers: for, by making more sail, if the wind be a little fresh, she will shoot a-head through the water, and drag the boarder with such force as to break the chains or hawsers by which the two ships are confined together. By laying all flat to the mast, the boarded vessel is still more likely to succeed, since the sails of one ship will be full, while those of the other are a-back.

This mode of boarding may, as shewn before, be anticipated and avoided, if the boarder does not pay the strictest attention to his own as well as to his adversary's manœuvres: but it may be still more readily avoided, if the last-mentioned vessel braces her head-sails sharp a-back, setting only, if necessary, the fore-sail (§. 37), at the same instant laying to the mast or shivering (according to the necessity for more or less sternway) all those which are abaft, (§. 36,) and putting the helm hard a-lee. (§. 58.) All this is to be executed when the boarder is still about a ship's length (more or less) a-stern of the other vessel. The quickness of this evolution, and the rapid veering of the weather-ship, may bring the boarding-vessel, which is a little to leeward or a-stern of the other, into the most dangerous situation, if she does not manœuvre
in

in the same manner and with equal celerity ; as the boarder's sails, being full, keep up his velocity, and may, before he can veer, engage his bowsprit in the main-shrouds of the enemy, who pays short round on her head.

This terrible and dangerous situation is infinitely to be dreaded ; and it is of the highest importance to pay the strictest attention to your own manœuvres, and to those of your opponent, which you are to endeavour to foresee and avoid as much as possible.

It is easy to conceive, that, if you wish to board a ship, and to engage your enemy's bowsprit in your main-shrouds, you need only get a little to windward of her, and about one or two ships' lengths a-head, more or less, as (from the knowledge you have of the celerity of your ship's movements) may be judged sufficient ; then brace sharp a-back the head-sails, shiver the after ones, or lay them flat to the mast, with the helm a-lee. This manœuvre, well executed, and covered by a brisk fire, will commonly succeed : but care must be taken not to come round too soon, but to range very close to your adversary ; because, if you should not be a-head enough of him, you might fail in boarding, by paying too short round, and then you would infallibly get your bowsprit foul of his fore-shrouds, which would be highly disadvantageous.

If you should find yourself too far a-head, the design will be frustrated, by your passing under the bowsprit of the enemy, who will however be thereby exposed to be raked at his head, if he does not manœuvre in the same manner and with equal swiftness as the boarding-vessel, which has the great advantage of priority.

It is absolutely necessary to range very close to the ship, whose bowsprit you wish to engage in your rigging ; because, if you attempted to execute this at only a ship's length large and to windward of your opponent, he has only, the instant he perceives your design, to put the helm hard a-lee and heave-in stays, if he does not choose to act in the same manner as you do. If this last method is properly executed, the two ships can only range very near each other and exchange their broadsides, and the lee-ship will immediately gain the wind of her adversary. Therefore, to execute this manœuvre well, the vessels must be nearly yard-arm and yard-arm.

If

If the boarder be at a certain distance aft on the weather-quarter, the ship, wishing to avoid boarding, must heave-in stays, as soon as the other vessel is in the act of veering, in order to close her to leeward. By this manœuvre they will find themselves head to head, so that they may fire reciprocally their broadsides, in passing on opposite directions, and the lee-ship will get to windward.

TO BOARD WITH THE WIND LARGE.

If two ships engage with the wind large, the boarding-vessel should keep as close as possible on the lee-quarter of the ship she means to attack thus, that she may execute this design, as has been shewn before, by coming rapidly to the wind, and being careful not to pass a-head of her opponent.

The weather-ship, to avoid being boarded, must act on her part as was directed in the preceding article, according to circumstances.

A ship may also be boarded on the weather-side, by conforming to what has been said of boarding to windward.

When two vessels are engaged, with the wind right aft, the ship, desirous of boarding, ought to drop a-stern of the enemy, in order to run up close along-side of him, if the boarder has the advantage of sailing; for, as she then advances towards her adversary, her adversary can only endeavour to range rapidly to the wind on the other tack, as soon as the bowsprit of the boarder is a-breast of her stern, and thus gain the wind, in order to be in a situation to extricate herself more easily by a good manœuvre.

The boarding-vessel should be permitted to come a-breast of the stern of her adversary before she hauls her wind; because, if she were to do this sooner, the ship a-stern, at a small distance, would board her perfectly well, even if they sail equally swift, since the boarder would be to windward, would run large longer than the other,

other, would range more slowly to the wind, and continue to stem a-head of the flying ship. What makes this more evident is, that the boarder, coming from windward, preserves longer his velocity, trimming his sails only as the ship comes to the wind, and cuts the course of his adversary with a line less curved than that described by the retreating ship.

If, by coming too soon or too fast to the wind, the boarder chose to abandon his design, he might do so by veering a few points on the other tack and shortening sail; so that the retreating ship will shew her stern, and the boarder can then rake her by passing under her stern.

When you attack a ship closely to leeward, you may keep away a little, when you are a-breast of her, seeming to yield under her fire. If this should induce the opposing ship to veer, in order to keep you more under her guns, you have only to heave rapidly to the wind, by putting the helm a-lee, trimming all sharp abaft, and suppressing the effect of the head-sails; all of which is to be done in the same instant you perceive the enemy bears down upon you. The quickness of this manœuvre, and the priority of the movement you gain thus on your enemy, will soon close the two ships; and, if proper attention be paid, and the distance well measured, it may happen that the enemy's bowsprit will be entangled in your fore or main rigging; which would be a most advantageous thing in your attempt to board. But much confidence must not be placed in this, as you do not frequently meet with persons so easily duped: it may even happen that you will no longer be able to attempt the boarding, if the weather-ship, instead of bearing away, plied to windward more and more; for this feint manœuvre may take you too far off to leeward of your adversary. If you should happen to be a ship's length to leeward, and about the same distance a-head of the vessel with which you are engaged, you may, under cover of a heavy fire, heave-in stays. By this manœuvre you come right athwart the enemy's hawse, rake him fore and aft, and board him, his bowsprit being right over your gangway; nor can he possibly avoid your broadside; for, if he heave all a-back and make a-stern board, which is his only resource, he may avoid being boarded, but will always be in a very bad situation.

BOARDING AT AN ANCHOR.

If it be intended to board a ship which is at an anchor, riding head to wind, it must be executed under sail; for, if you cannot approach the enemy but by towing yourself a-head, you will never be able to board her against her will; since it will always be in her power to annoy the boats which are laying out the tow-lines. It ought not, therefore, to be attempted, unless you are under way. To perform this with success, you must be sufficiently to windward to approach her by a little falling off, without exposing your stern to her fire, which she could play on you with great advantage in this situation. Supposing, therefore, the boarder to be thus to windward, so as to be able to approach his opponent at anchor, the assailant ought to stop his headway, by taking a-back his mizen-topfail and fore-stayfail, and, when about a ship's length a-head of the vessel he means to board, let go an anchor; then work in such a manner, that, as soon as the mizen-topfail is taken a-back, the mizen close aft, the topfails clued up, and the fore-top-mast-stayfail hauled down, he may come head to wind, and veer away cable, till, by falling off, he comes board-and-board with his opponent, who is still riding at her moorings, and who, at that instant, ought also to be raked by the boarder.

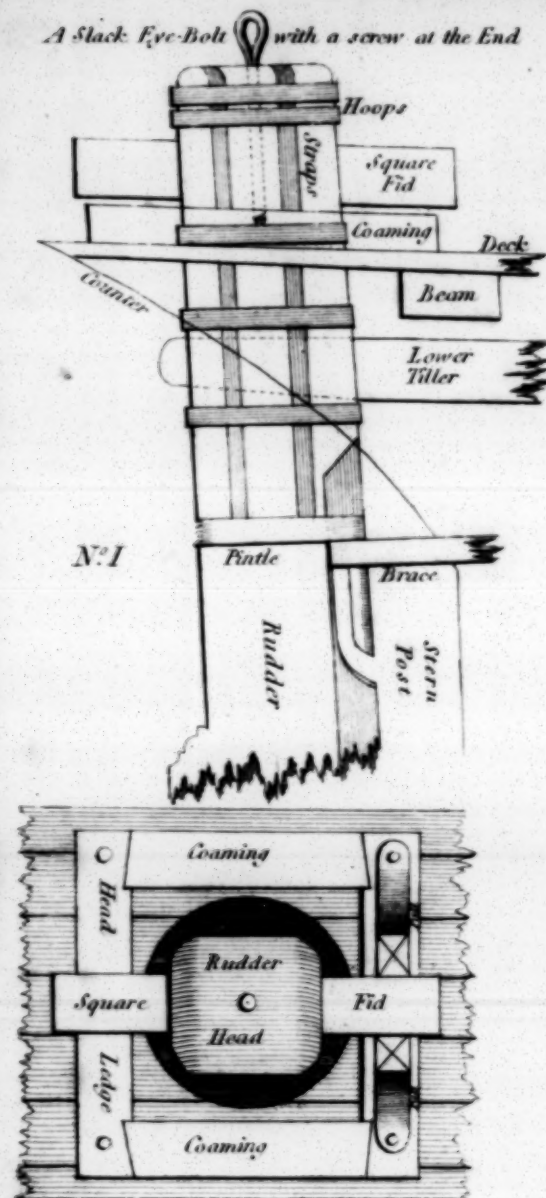
The boarding-ship has no other way of manœuvring but this; because, as soon as the anchor is gone, the ship acquires stern-way; and, when the cable is checked, she comes head to wind, in which she is greatly assisted by the mizen and mizen-topfail, which impel her stern to leeward (§. 40 and 44), till the wind is right in the direction of the keel; and, as the cable is veered away till exactly along-side the ship at anchor, her own anchor being right a-head of the vessel she means to board, it follows, that, as soon as the boarding-ship comes head to wind, she is in a proper situation to throw her grapnels, and send her crew on board of the other, if they are the strongest.

The ship at anchor should never wait for the enemy in that situation, which is always disadvantageous, and there is always much greater probability of getting clear when under way. But if, for some unforeseen cause, you are obliged to continue at anchor, you are to take advantage of the moment, when the ship which attacks lets go her anchor, to cut the cable by which you ride. By this manœuvre you fall athwart, rake your adversary, avoid being boarded, and bring up with your lee-anchor. Besides, if time will admit before the attack, you should not neglect to cast two springs out, one on each side of the cable by which the vessel rides, if you have not had time before to lay out two anchors, in order not to be surpris'd, in case the ship which attacks has it in her power to pass on either side of you: and, when you perceive for which side she is determin'd, you heave on the spring which is on the same side she has let go her anchor if she be a-head, and on the opposite if she be a-stern, veering out at the same time the other spring and cable, till you bring the assailant right a-breast of you. Then you may rake him at pleasure, as he has no way of getting out of this dangerous situation. His only course would be to prevent this danger by having a spring also; and, under cover of a brisk fire, veer upon that spring and cable to lay his enemy handsomely on board. But, if he has neglected this precaution, he must cut his cable, and drop on board of the ship to leeward; who, on the other hand, has no way to avoid being boarded, but by cutting, to get under way or to run on shore.

It is always easy to board a ship at anchor, when the wind will allow you to approach her under sail; and the best way to proceed is, to run her along-side, or to bring-to to windward of the ship you wish to attack, keeping her exactly to leeward of you; then drift on board of her, by trimming your sails in such a manner, as to keep, as near as possible, your broadside opposite to that of the adverse ship; annoying her with your guns till you can close her, and your constant cannonading may prevent her fire being so well served as it might otherwise be.

When you are under way, and purpose to board a vessel moored, let go an anchor at the time of boarding; for, if the ship attacked should

Inventions for Saving a Rudder when beaten off.



N^o I consists of a square fid made to fit the upper hole of the rudder and bolted through the rudder head. It has likewise a Coaming fitted round the rudder hole and well secured to the Deck, for the fid to work on, acting as an upper gudgeon, in case the pintles are beaten off. Palls are bolted through the fore part of the Coaming, to quiet the Rudder, in the room of Chocks, in case the tiller should be carried away.

N^o II consists of a circular rim of Oak or Elm, bolted and dented round the rudder hole, from 9 to 12 In. broad and 9 Inches thick at the fore part, decreasing its depth aft, so that its surface may be square with the rudder-head. In the middle of the rim, on the upper surface there is let in, one half of its thickness, & screwed, an Iron Plate, about 4 Inches broad & half an Inch thick. On the forepart of the Plate, on each side of the middle line, are punched holes, that are bored through the Deck, to receive Iron shouldered bolts; by placing one of which on each side of the Iron bolt which goes through the rudder head, the rudder is secured when the tiller is broken. An Iron bolt at the height of the circular rim is driven through the rudder head & an Iron hoop on the head of the rudder.

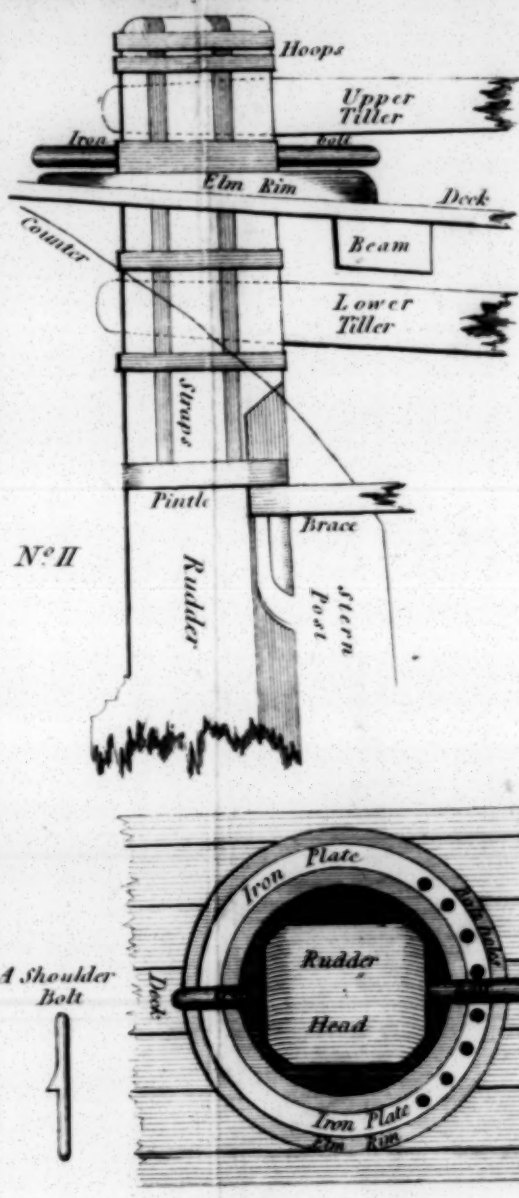
The Deck represented in both these drawings is the middle deck in three decked Ships, and the upper Deck in two decked Ships.

The Sole of Rudders is recommended to be 9 or 12 inches in depth: by which in case of partially grounding, the Rudder may be saved with the loss of the Sole only.

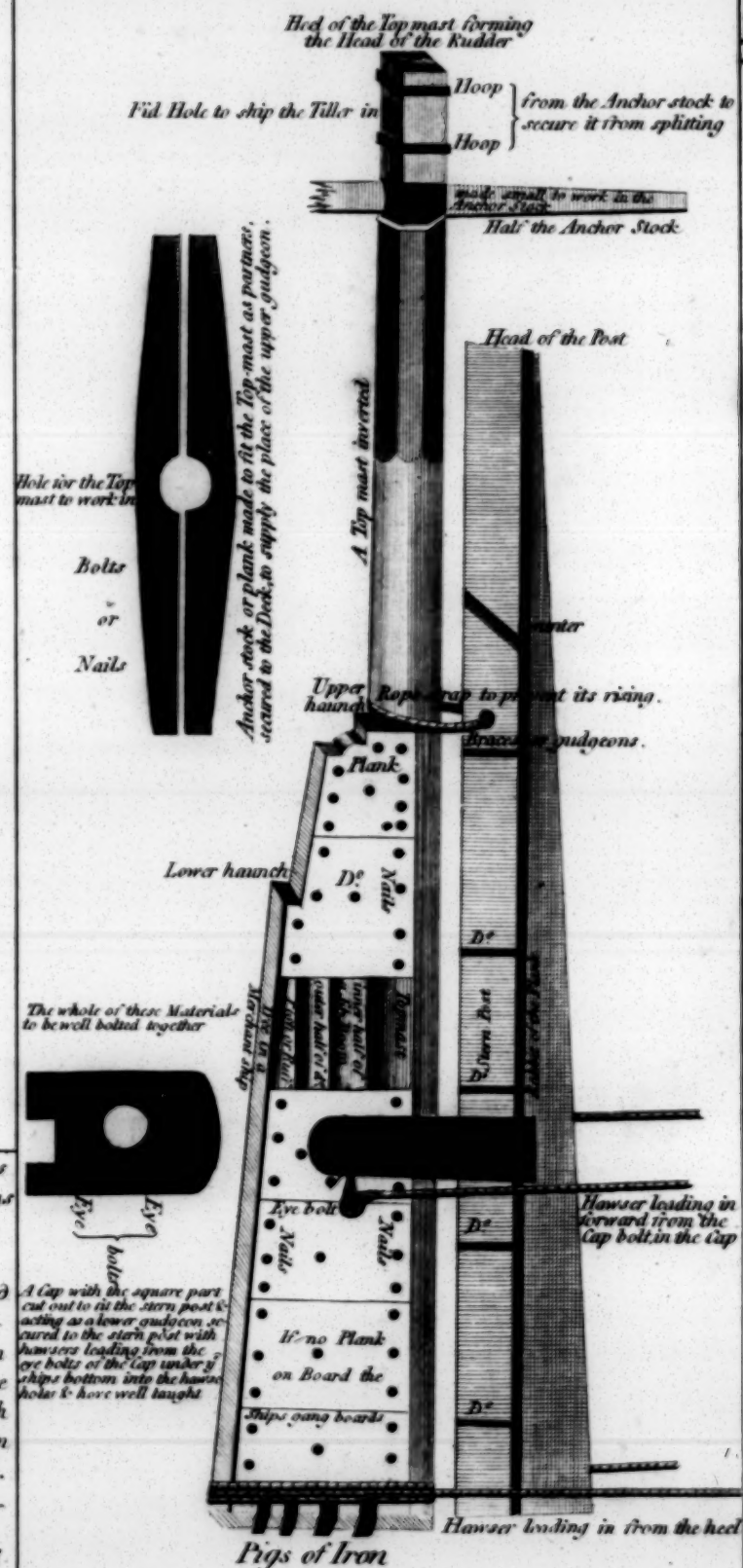
This second plan is equally applicable to Ships that steer with a tiller on deck, by having the Coaming fixed upon the Deck immediately underneath the tiller; & it is presumed to possess these other advantages: the upper tiller hole is preserved vacant for use, in case the lower tiller be broken; the round bolt through the Rudder will work upon the circular plate, as an upper gudgeon, with less friction; and the shouldered bolts will stop the rudder when in any direction.

METHOD of Steering with the Wheel from the upper tiller, in cases when the lower tiller is broken. *Viz.* Three-decked Ships are fitted with a block in mid-ships, under the upper deck (the same as is fixed under the middle deck) that the upper tiller may be connected to the Wheel by ropes leading from the Wheel, through the Block under the upper deck, thence through a Block fixed in the side, and thence to the upper Tiller.

All three-decked Ships are, by order of the Admiralty, to be fitted with a Block for this purpose.



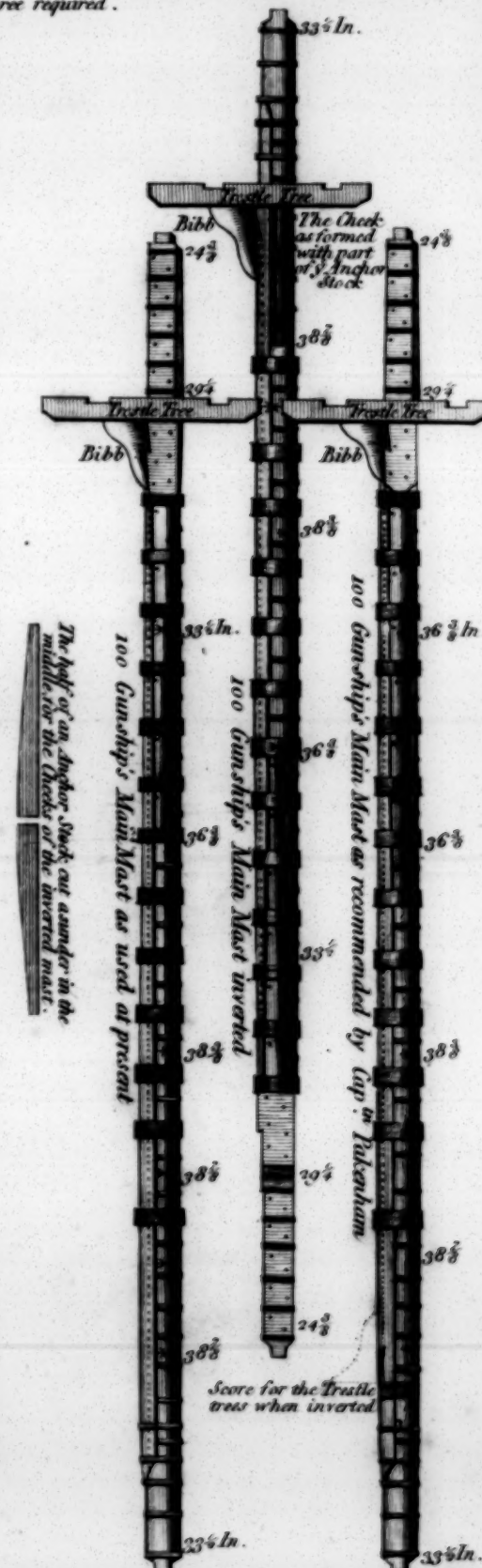
Substitute for a Rudder when lost.



The rudder is made to sink by Rigs of Iron, by Ballast, or by an Anchor, at the lower part; which are removed when it is fixed.

*Method of restoring Masts when wounded
by inverting them.*

* If the wound is within such a distance from the head as is beneath the deck, the mast, when inverted, will be as good as new; as it may be fished and secured to any degree required.



When the Mast is making, the Tenon at the Heel should be made to fit the square hole in the Cap. And when inverted, by letting in the Trestle Trees one third of their thickness, a bed is formed for bolting them to the mast and one of the two pieces of Oak that form the Anchor Stock is sawed asunder in the middle will when fayed, and bolted on the Thwart ship sides of the mast, make cheeks & stops to support the Trestle Trees.

should at this moment cut her cables to drive on shore, this would prevent your running a-ground together.

CAPT. PAKENHAM'S INVENTIONS.

On the opposite plate will be found an accurate representation and a full description of Capt. Pakenham's very useful inventions.

THE END.



BY AUTHORITY.

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